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# NAVAL POSTGRADUATE SCHOOL

## Monterey, California

HYDROGRAPHIC DATA FROM THE OPTOMA PROGRAM
OPTOMA4, LEGS I AND II
26 MARCH - 10 APRIL, 1983

by

Michele M. Rienecker
Paul A. Wittmann
Edward A. Kelley
Marie C. Colton
Christopher N.K. Mooers

January 1985

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of Naval Research
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NAVAL POSTGRADUATE SCHOOL

Monterey, California 93943

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The cruise OPTOMA4 was undertaken in March and April, 1983 to sample two subdomains of the California Current System. This report presents the hydrographic data, acquired by XBT and CTD casts, from the cruise.

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# *Hydrographic Data from the* **OPTOMA** *Program: OPTOMA4, Legs I and II*

*26 March - 10 April, 1983*

*by*

*Michele M. Rienecker*
*Paul A. Wittmann*
*Edward A. Kelley*
*Marie C. Colton*
*Christopher N. K. Mooers*

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Cambridge, MA 02138.

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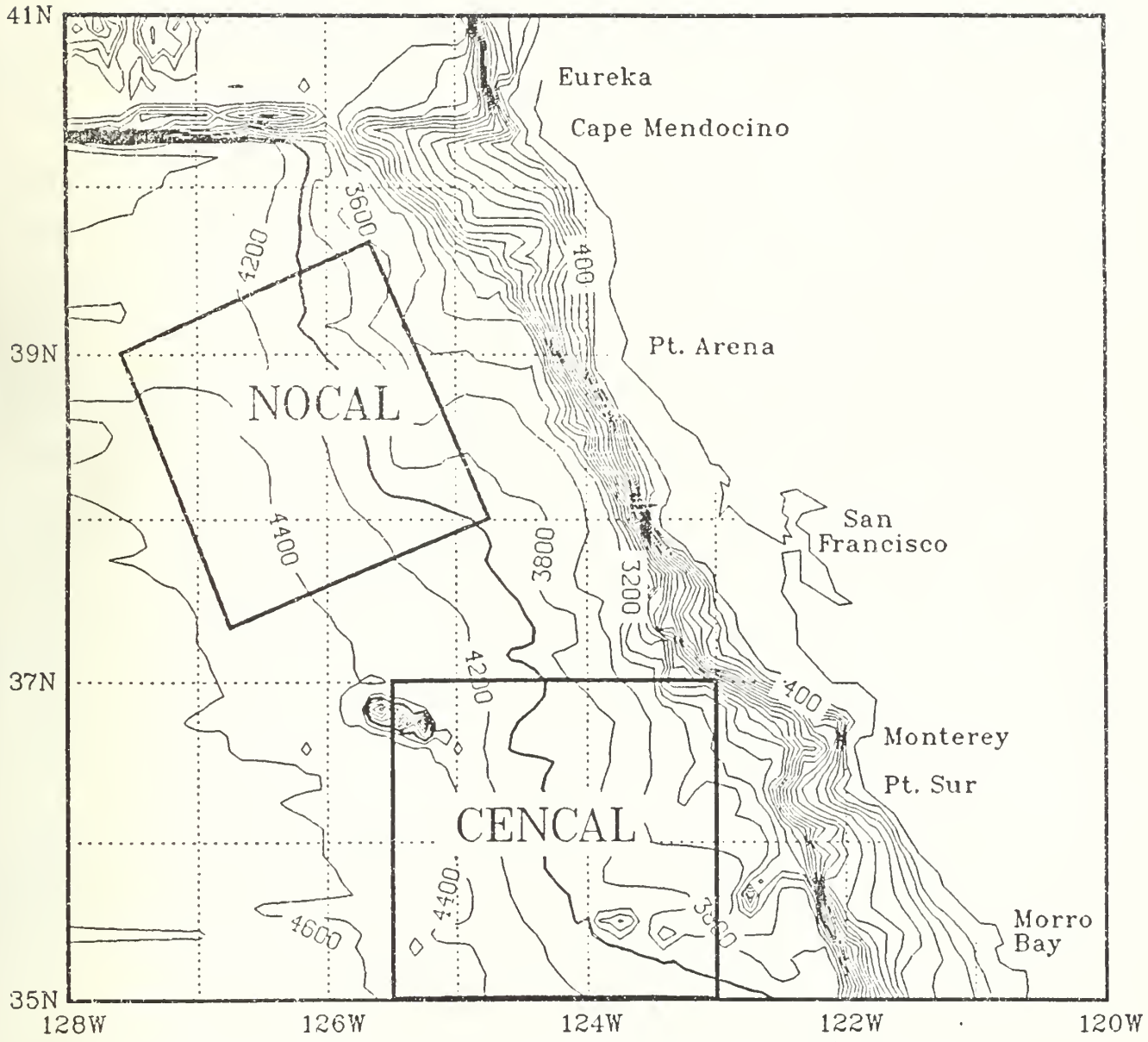


Figure 1: The NOCAL and CENCAL subdomains of the OPTOMA Program. Isobaths are shown in meters.

## INTRODUCTION

The OPTOMA (Ocean Prediction Through Observations, Modeling and Analysis) Program, a joint NPS/Harvard program sponsored by ONR, seeks to understand the mesoscale (fronts, eddies, and jets) variability and dynamics of the California Current System and to determine the scientific limits to practical mesoscale ocean forecasting. To help carry out the aims of this project, a series of cruises has been planned in two subdomains, NOCAL and CENCAL, shown in Figure 1.

The cruise OPTOMA4 was undertaken, in the R/V ACANIA, for two weeks in March and April, 1983 and covered parts of the NOCAL and CENCAL domains, each roughly 200 km square centered 150 km off the California coast from Pt. Arena and Pt. Sur, respectively.

Hydrographic data were acquired during two legs: Leg I was carried out during the period 26 March to 1 April and sampled an area 160 km cross-shore by 170 km alongshore with additional transects to and from the NOCAL domain as shown in Figure 2. The transect extremes are identified by letter to aid in the cross-referencing of data presented in subsequent figures. Leg II was carried out during the period 5 to 10 April and sampled an area, approximately 160 km cross-shore by 170 km alongshore, in the CENCAL domain as shown in Figure 13. Each leg consisted of a series of three parallel transects directed alongshore, separated by roughly 80 km and along which hydrographic stations were occupied every 18.5 km. In addition, there were three diagonal transects and tracks to and from the domain.

## DATA ACQUISITION

Data acquired during OPTOMA4 include XBT and CTD profiles and continuous 2 m thermalsalinograph measurements. Bucket surface temperature and water samples for salinity were taken at every CTD station. These surface values

and those at 2 m were used for calibration purposes as well as contributions to the data base. Continuous meteorological data such as atmospheric pressure at a height of 2 m and wind speed and direction at a height of 20 m were also recorded. The XBT, CTD and continuous "underway" data were digitized using an HP 5328 frequency counter and a 40 channel digital voltmeter. The continuous data were averaged over one-minute intervals. All data were recorded, using an HP 9835 computer, on data cassettes and transferred ashore to the IBM 3033 mainframe computer for editing and processing.

Station positions were determined by Loran C fixes and are claimed to be accurate to within about 0.1 km. Table 1 on page 5 summarizes the various sensors available on the R/V ACANIA and their accuracy. The bottle surface salinity samples were determined ashore by a Guildline Model 8400 "Autosal" salinometer with an accuracy of $\pm$0.003 ppt.

DATA PROCESSING

Data processing, such as estimating depth profiles for the XBT temperature profiles based on the XBT's descent speed, and conversion of CTD conductivity to salinity using the algorithm given in Lewis and Perkin (1981), was carried out on the IBM 3033 at the Naval Postgraduate School. The data were then edited by removing obvious salinity spikes and eliminating cast failures that were not identified during the cruise. Approximately 91% of casts were retained in the data set of Leg I and 94% in the data set of Leg II. The average difference between the surface salinity values from the bottle samples and the CTD's was less than 0.01 ppt for each leg, so no correction was made to the CTD salinity values. The CTD data were interpolated to 5 m intervals and then up and down casts were averaged.

The data have been transferred on digital tape to the National Oceanographic Data Center in Washington, DC.

DATA PRESENTATION

The cruise track, station locations (with XBT's and CTD's identified) and station numbers are shown in the first three figures of each of the next two sections, which present the data from Leg I and Leg II, respectively. These figures are followed by a listing of the stations, with their coordinates, the date and time at which the station was occupied, and the surface information obtained at the station.

Vertical profiles of temperature from the XBT casts are shown in staggered fashion. The location of these profiles may be found by reference to the various maps of the cruise track. Transect extremes are identified as nearly as possible. The first profile on each plot is shown with its temperature unchanged; to each subsequent profile an appropriate multiple of 5C has been added. Vertical profiles from the CTD's follow. Profiles of temperature are staggered by 5C and those of salinity by 4 ppt.

Isotherms for each transect are shown in the next pages, followed by isopleths of temperature, salinity and sigma-t from the CTD's. Based on instrument accuracy and the vertical temperature gradient, it is estimated that depths of isotherms in the main thermocline are uncertain to $\pm$20m. The tick marks identify station positions and, again, the transect extremes are shown on these plots.

Each section includes mean profiles of temperature from the XBT's and temperature, salinity and sigma-t from the CTD's as well as a scatter diagram of the T-S pairs and the mean S(T) curve with the $\pm$ standard deviation envelope. The data presentation concludes with a plot of the mean $N^2$ (Brunt-Vaisala frequency squared) profile with $\pm$ the standard deviation. On the sigma-t and $N^2$ plots, the appropriate profiles derived from the mean temperature and mean salinity profiles are also shown.

Table 1: Scientific instruments aboard the R/V ACANIA

| | Instrument | Variable | Sensor | Accuracy | Resolution |
|---|---|---|---|---|---|
| | Neil Brown CTD Mark IIIb | pressure | strain gage | 1.6 db | 0.025 db |
| | | temperature | thermistor | 0.005 C | 0.0005 C |
| | | conductivity | electrode cell | 0.005 mmho | 0.001 mmho |
| | Sippican BT | temperature | thermistor | 0.2 C | |
| | | depth | descent speed | greater of 4.6 m and 2% of depth | |
| * | Guildline Autosal | conductivity | electrode cell | 0.003 ppt | 0.0002 ppt |
| * | Amatek straza ADVP | velocity profiles to 100m | 4 beam sonar | 3 cm/sec relative to ship speed | 3 cm/sec |
| * | Rosemount Sensor | sea surface temperature | platinum thermometer | 0.05 C | 0.005 C |
| | Sea-Bird Sensors | temperature | thermistor | 0.003 C | 0.0005 C |
| | | conductivity at 2 meters | electrode cell | 0.003 mmho | 0.0005 mmho |
| | Rosemount Sensor | air temperature | thermometer | 0.01 C | |
| | Kavolico Barometer | atmospheric pressure | pressure transducer | 1.5 mb | 0.1 mb |
| * | 1200 EPS Hygrometer | dew point | condensation temp. sensor | 0.2 C | 0.02 C |
| | Meteorology Res. Inc. | wind speed | anemometer | 0.15 mph or 1% | |
| | Meteorology Res. Inc. | wind direction | vane | 2.5 degrees | |
| | Internav LC408 LORAN C | position | two chain LORAN receiver | 100 meters | 10 meters |
| | Motorola Miniranger | position | microwave transponders | 4 meters | 2 meters |

* Not operating on the OPTOMA4 cruise.

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# SECTION 1

## OPTOMA4 Leg I

## 26 March - 1 April 1983

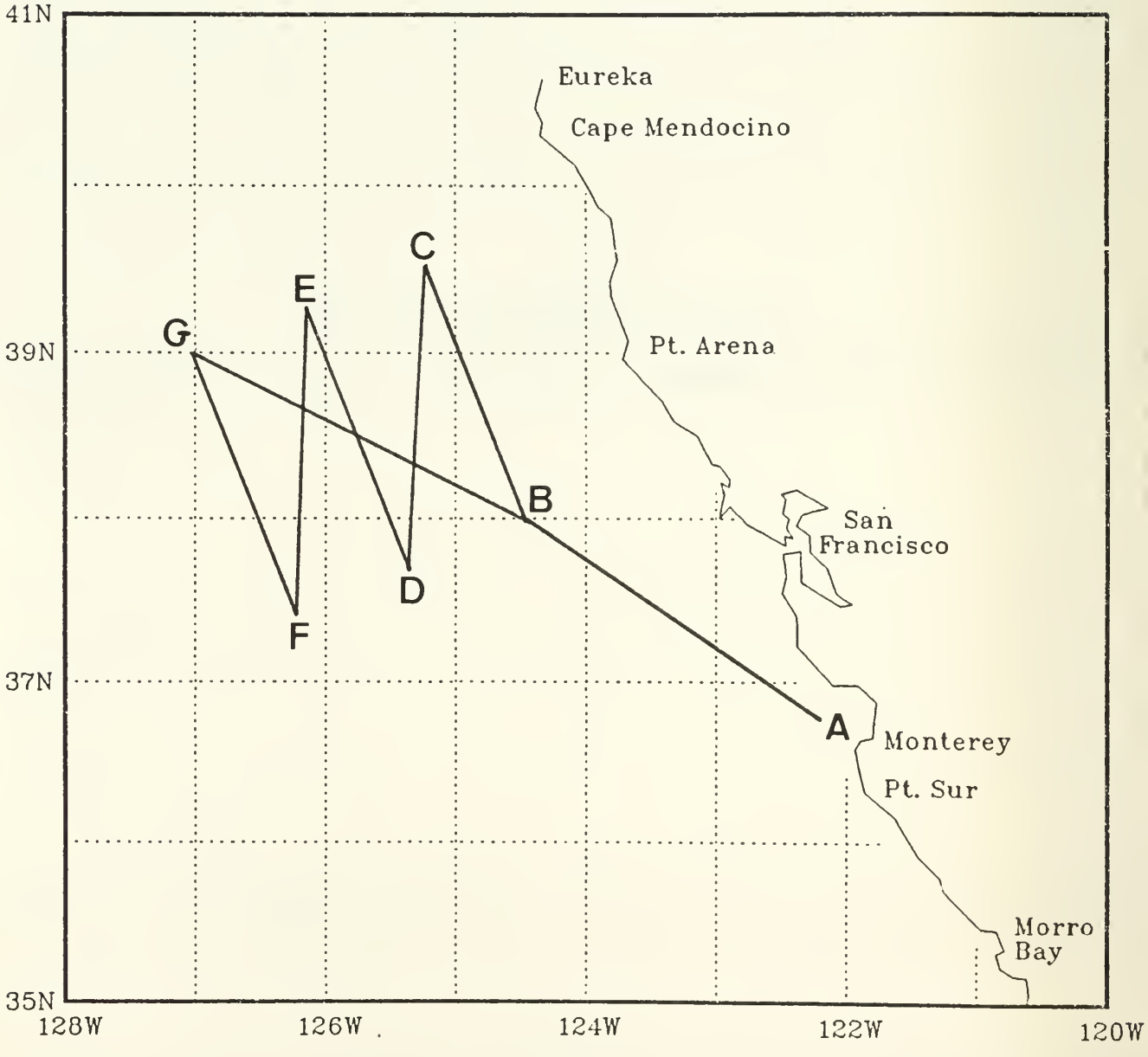



Figure 2: Cruise track for OPTOMA4, Leg I with transect extremes identified by letter.

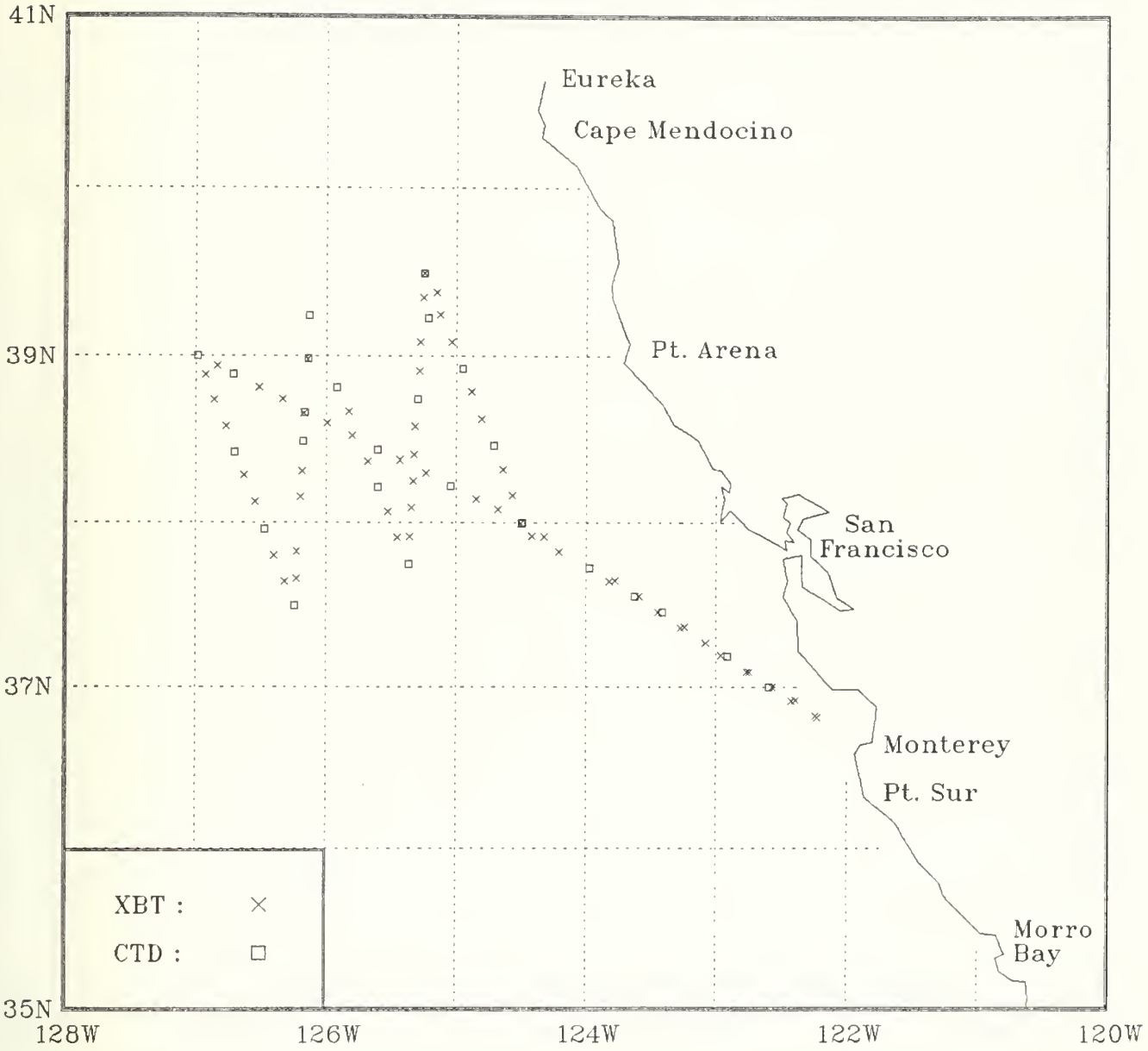



Figure 3: XBT and CTD locations for OPTOMA4, Leg I.

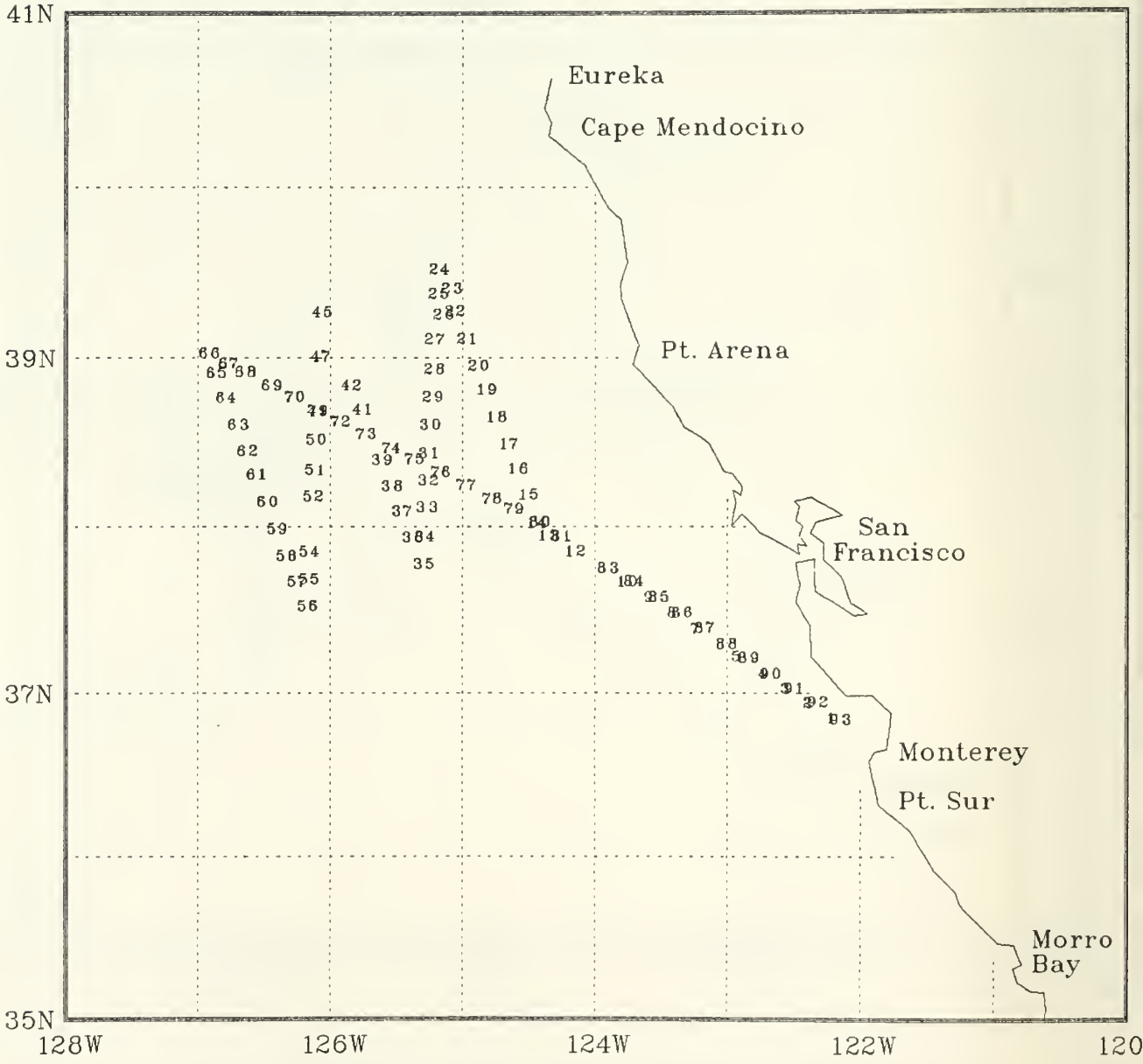



Figure 4: Station numbers for OPTOMA4, Leg I.

Table 2: Leg I Station Listing

| STN | TYPE | YR/DAY | GMT | LAT (NORTH) (DD.MM) | LONG (WEST) (DDD.MM) | SURFACE TEMP (DEG C) | SURFACE SALINITY (PPT) | BUCKET TEMP (DEG C) | BOTTLE SALINITY (PPT) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | XBT | 83085 | 2006 | 36.49 | 122.14 | 13.7 | | | |
| 2 | XBT | 83085 | 2121 | 36.55 | 122.25 | 13.9 | | | |
| 3 | CTD | 83085 | 2238 | 37.00 | 122.35 | 13.5 | 32.43 | 13.6 | 32.47 |
| 4 | XBT | 83086 | 8 | 37.06 | 122.46 | 13.1 | | | |
| 5 | XBT | 83086 | 128 | 37.12 | 122.58 | 13.1 | | | |
| 7 | XBT | 83086 | 334 | 37.22 | 123.16 | 13.0 | | | |
| 8 | XBT | 83086 | 446 | 37.28 | 123.27 | 13.0 | | | |
| 9 | CTD | 83086 | 559 | 37.33 | 123.38 | 12.6 | 32.57 | 12.8 | 32.57 |
| 10 | XBT | 83086 | 818 | 37.39 | 123.49 | 13.8 | | | |
| 12 | XBT | 83086 | 1325 | 37.50 | 124.13 | 12.9 | | | |
| 13 | XBT | 83086 | 1500 | 37.55 | 124.25 | 13.0 | | | |
| 14 | CTD | 83086 | 1649 | 38.00 | 124.30 | 13.1 | 33.04 | 13.1 | 33.03 |
| 14 | XBT | 83086 | 1724 | 38.00 | 124.30 | 13.2 | | | |
| 15 | XBT | 83086 | 1854 | 38.10 | 124.34 | 13.0 | | | |
| 16 | XBT | 83086 | 2005 | 38.19 | 124.39 | 13.1 | | | |
| 17 | CTD | 83086 | 2111 | 38.28 | 124.43 | 13.0 | 32.88 | 12.9 | 32.85 |
| 18 | XBT | 83086 | 2253 | 38.38 | 124.49 | 12.6 | | | |
| 19 | XBT | 83087 | 10 | 38.47 | 124.53 | 12.6 | | | |
| 20 | CTD | 83087 | 120 | 38.56 | 124.57 | 12.6 | 32.73 | 12.6 | 32.78 |
| 21 | XBT | 83087 | 308 | 39.05 | 125.02 | 12.3 | | | |
| 22 | XBT | 83087 | 429 | 39.15 | 125.08 | 12.6 | | | |
| 23 | XBT | 83087 | 531 | 39.23 | 125.09 | 12.2 | | | |
| 24 | CTD | 83087 | 705 | 39.30 | 125.15 | 12.2 | 32.71 | 12.1 | 32.74 |
| 24 | XBT | 83087 | 744 | 39.30 | 125.15 | 12.2 | | | |
| 25 | XBT | 83087 | 842 | 39.21 | 125.15 | 12.8 | | | |
| 26 | CTD | 83087 | 942 | 39.14 | 125.13 | 12.5 | 32.80 | 12.2 | 32.80 |
| 27 | XBT | 83087 | 1114 | 39.05 | 125.17 | 12.3 | | | |
| 28 | XBT | 83087 | 1232 | 38.55 | 125.17 | 12.5 | | | |
| 29 | CTD | 83087 | 1348 | 38.45 | 125.18 | 12.4 | 32.77 | 12.2 | 32.79 |
| 30 | XBT | 83087 | 1526 | 38.35 | 125.19 | 12.3 | | | |
| 31 | XBT | 83087 | 1642 | 38.25 | 125.20 | 12.3 | | | |
| 32 | XBT | 83087 | 1812 | 38.15 | 125.20 | 13.1 | | | |
| 33 | XBT | 83087 | 1935 | 38.05 | 125.21 | 13.1 | | | |
| 34 | XBT | 83087 | 2055 | 37.55 | 125.21 | 13.3 | | | |
| 35 | CTD | 83087 | 2208 | 37.45 | 125.22 | 13.5 | 33.10 | 13.5 | 33.08 |
| 36 | XBT | 83088 | 44 | 37.55 | 125.27 | 13.1 | | | |
| 37 | XBT | 83088 | 158 | 38.04 | 125.32 | 13.1 | | | |
| 38 | CTD | 83088 | 307 | 38.13 | 125.36 | 13.2 | 33.02 | 13.2 | 33.03 |
| 39 | XBT | 83088 | 436 | 38.22 | 125.41 | 12.9 | | | |
| 41 | XBT | 83088 | 744 | 38.40 | 125.50 | 12.2 | | | |
| 42 | CTD | 83088 | 848 | 38.49 | 125.55 | 12.4 | 32.84 | 12.5 | 32.82 |
| 45 | CTD | 83088 | 1231 | 39.15 | 126.08 | 11.7 | 32.66 | 11.9 | 32.63 |
| 47 | CTD | 83088 | 1641 | 38.59 | 126.08 | 12.3 | 32.69 | 12.2 | 32.86 |
| 47 | XBT | 83088 | 1658 | 38.59 | 126.09 | 12.4 | | | |
| 49 | XBT | 83088 | 2045 | 38.40 | 126.10 | 12.1 | | | |

| STN | TYPE | YR/DAY | GMT | LAT (NORTH) (DD.MM) | LONG (WEST) (DDD.MM) | SURFACE TEMP (DEG C) | SURFACE SALINITY (PPT) | BUCKET TEMP (DEG C) | BOTTLE SALINITY (PPT) |
|---|---|---|---|---|---|---|---|---|---|
| 50 | CTD | 83088 | 2224 | 38.30 | 126.11 | 12.7 | 32.94 | 12.9 | 32.91 |
| 51 | XBT | 83089 | 35 | 38.19 | 126.11 | 12.7 | | | |
| 52 | XBT | 83089 | 155 | 38.09 | 126.12 | 12.7 | | | |
| 54 | XBT | 83089 | 509 | 37.50 | 126.14 | 13.1 | | | |
| 55 | XBT | 83089 | 638 | 37.40 | 126.14 | 13.2 | | | |
| 56 | CTD | 83089 | 753 | 37.30 | 126.15 | 12.8 | 32.86 | 12.9 | 32.85 |
| 57 | XBT | 83089 | 1009 | 37.39 | 126.19 | 12.6 | | | |
| 58 | XBT | 83089 | 1121 | 37.48 | 126.24 | 12.8 | | | |
| 59 | CTD | 83089 | 1233 | 37.58 | 126.28 | 12.6 | 32.86 | 12.7 | 32.83 |
| 60 | XBT | 83089 | 1410 | 38.07 | 126.33 | 12.7 | | | |
| 61 | XBT | 83089 | 1521 | 38.17 | 126.38 | 12.9 | | | |
| 62 | CTD | 83089 | 1626 | 38.26 | 126.42 | 12.5 | 32.83 | 12.8 | 32.87 |
| 63 | XBT | 83089 | 1754 | 38.35 | 126.46 | 12.5 | | | |
| 64 | XBT | 83089 | 1900 | 38.44 | 126.52 | 11.8 | | | |
| 65 | XBT | 83089 | 2004 | 38.53 | 126.56 | 12.0 | | | |
| 66 | CTD | 83089 | 2056 | 39.00 | 126.59 | 12.0 | 32.81 | 12.4 | 32.83 |
| 67 | XBT | 83089 | 2251 | 38.57 | 126.50 | 12.7 | | | |
| 68 | CTD | 83089 | 2336 | 38.54 | 126.43 | 12.2 | 32.84 | 12.5 | 32.83 |
| 69 | XBT | 83090 | 106 | 38.49 | 126.31 | 12.5 | | | |
| 70 | XBT | 83090 | 205 | 38.45 | 126.20 | 12.6 | | | |
| 71 | CTD | 83090 | 309 | 38.40 | 126.10 | 12.3 | 32.86 | 12.4 | 32.87 |
| 72 | XBT | 83090 | 428 | 38.36 | 126.00 | 12.8 | | | |
| 73 | XBT | 83090 | 533 | 38.32 | 125.48 | 12.8 | | | |
| 74 | CTD | 83090 | 645 | 38.27 | 125.36 | 12.8 | 32.90 | 12.7 | 32.87 |
| 75 | XBT | 83090 | 846 | 38.23 | 125.26 | 12.7 | | | |
| 76 | XBT | 83090 | 954 | 38.18 | 125.14 | 12.5 | | | |
| 77 | CTD | 83090 | 1104 | 38.13 | 125.03 | 12.5 | 32.77 | 12.6 | 32.77 |
| 78 | XBT | 83090 | 1235 | 38.08 | 124.51 | 13.1 | | | |
| 79 | XBT | 83090 | 1329 | 38.05 | 124.41 | 13.7 | | | |
| 80 | CTD | 83090 | 1432 | 38.00 | 124.30 | 13.2 | 32.94 | 13.2 | 32.96 |
| 81 | XBT | 83090 | 1638 | 37.55 | 124.20 | 13.7 | | | |
| 83 | CTD | 83090 | 1849 | 37.44 | 123.59 | 13.1 | 32.91 | 13.1 | 32.92 |
| 84 | XBT | 83090 | 2023 | 37.39 | 123.47 | 13.4 | | | |
| 85 | XBT | 83090 | 2136 | 37.33 | 123.35 | 13.8 | | | |
| 86 | CTD | 83090 | 2247 | 37.27 | 123.25 | 13.3 | 31.42 | 13.4 | 31.43 |
| 87 | XBT | 83091 | 29 | 37.22 | 123.15 | 13.5 | | | |
| 88 | XBT | 83091 | 130 | 37.16 | 123.05 | 13.5 | | | |
| 89 | CTD | 83091 | 231 | 37.11 | 122.55 | 13.5 | 31.71 | 13.5 | 31.70 |
| 91 | XBT | 83091 | 454 | 37.00 | 122.34 | 14.1 | | | |
| 92 | XBT | 83091 | 558 | 36.55 | 122.24 | 14.0 | | | |
| 93 | XBT | 83091 | 705 | 36.49 | 122.13 | 13.8 | | | |

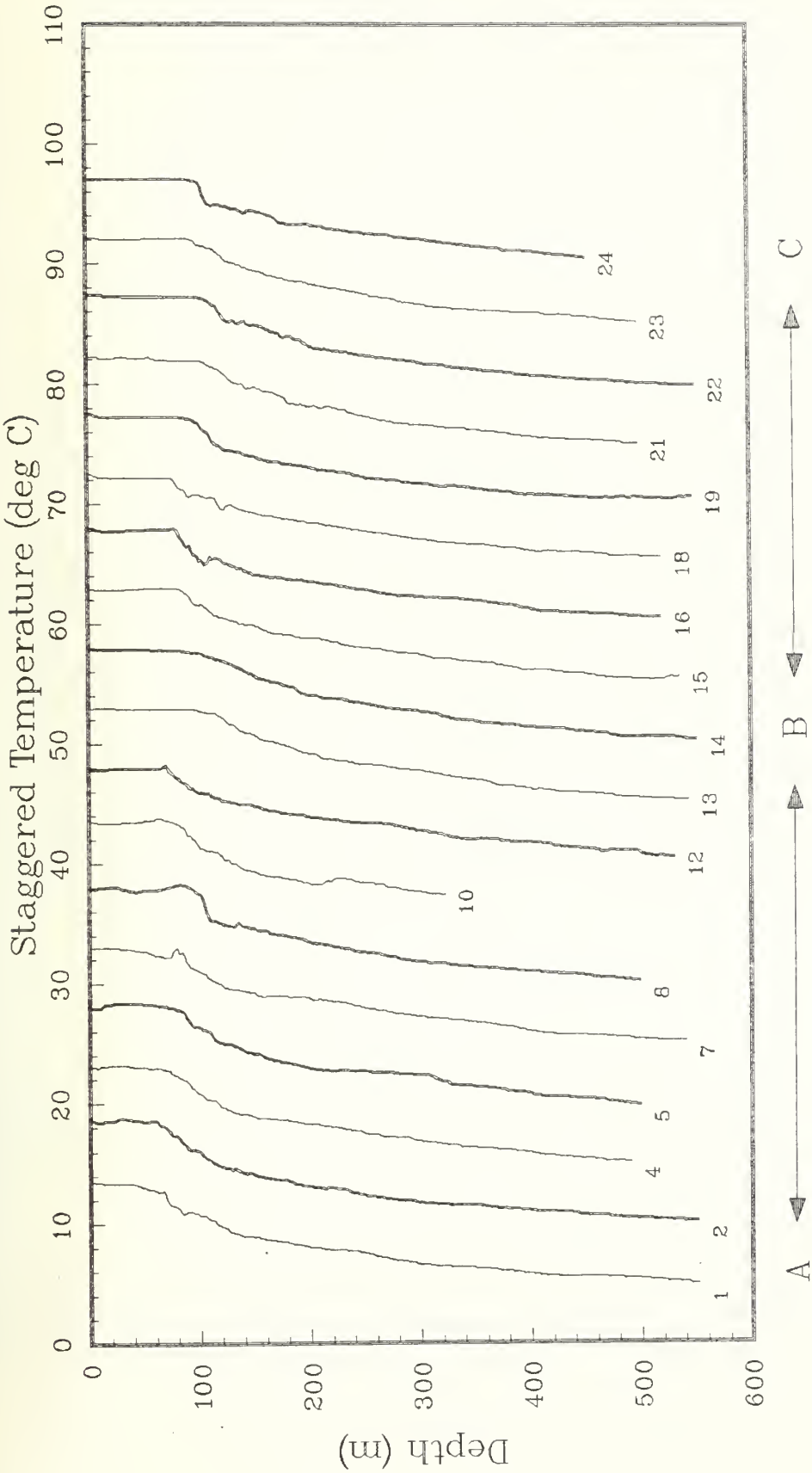



Figure 5(a): Staggered temperature profiles from the XBT's. Profiles are staggered by a multiple of 5C (OPTOMA4, Leg I).

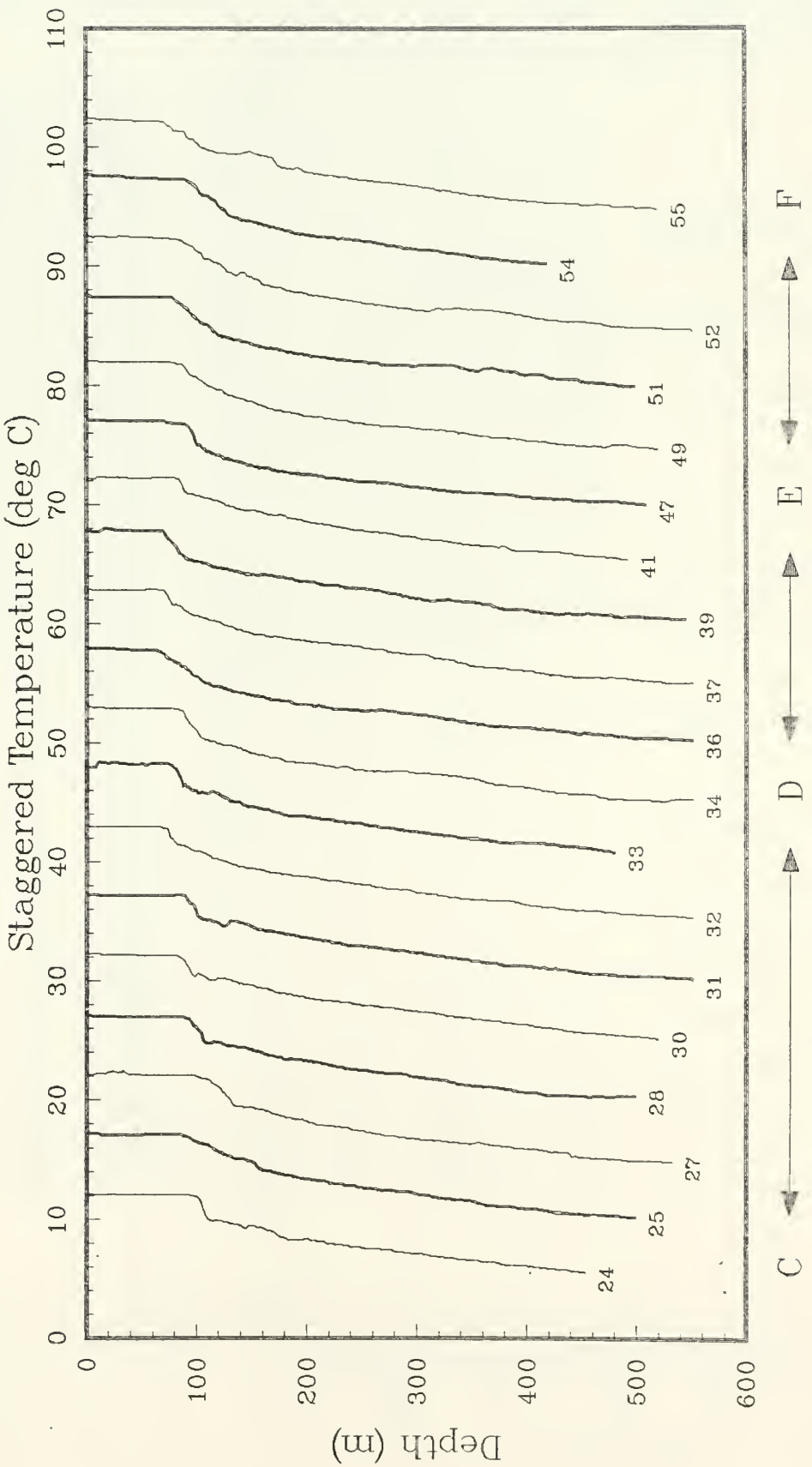

Staggered Temperature (deg C)
0
10
20
30
40
50
60
70
80
90
100
110
Depth (m)
0
100
200
300
400
500
600
24
25
27
28
30
31
32
33
34
36
37
39
41
47
49
51
52
54
55
C
D
E
F

Figure 5(b)

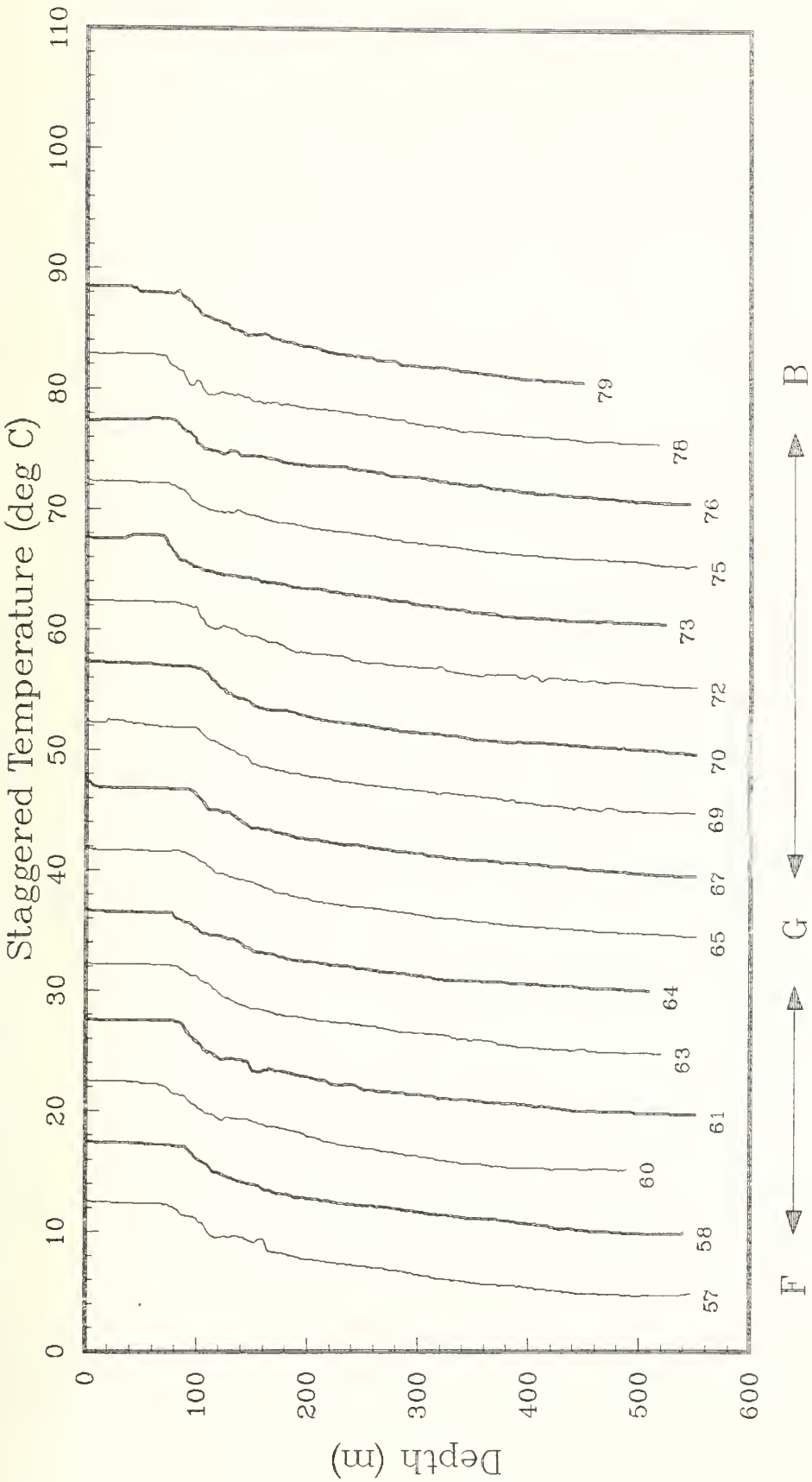

Staggered Temperature (deg C)
0
10
20
30
40
50
60
70
80
90
100
110
Depth (m)
0
100
200
300
400
500
600
57
58
60
61
63
64
65
67
69
70
72
73
75
76
78
79
F
G
B

Figure 5(c)

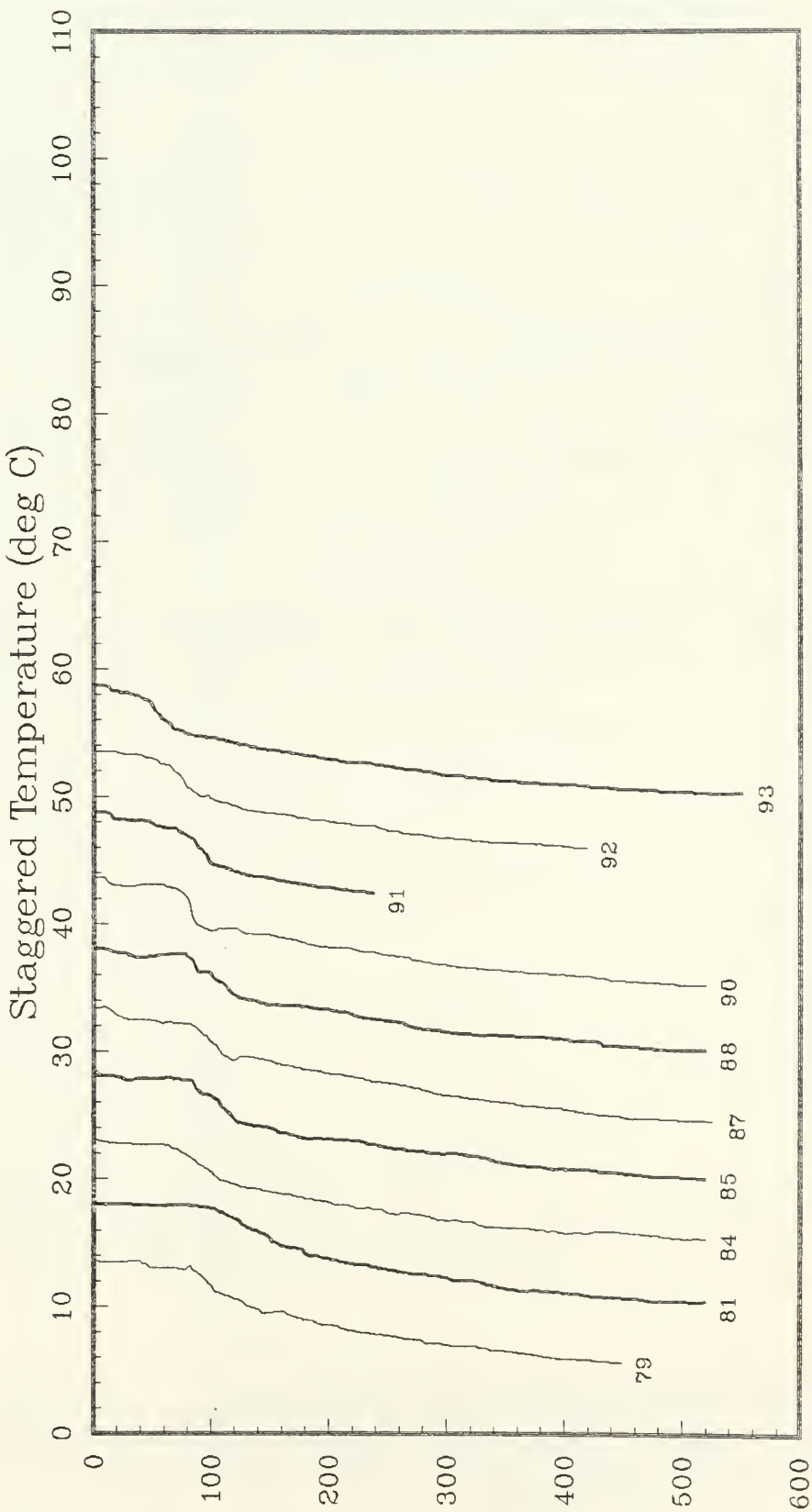

Staggered Temperature (deg C)
0
10
20
30
40
50
60
70
80
90
100
110
Depth (m)
0
100
200
300
400
500
600
79
81
84
85
87
88
90
91
92
93
B
A

Figure 5(d)

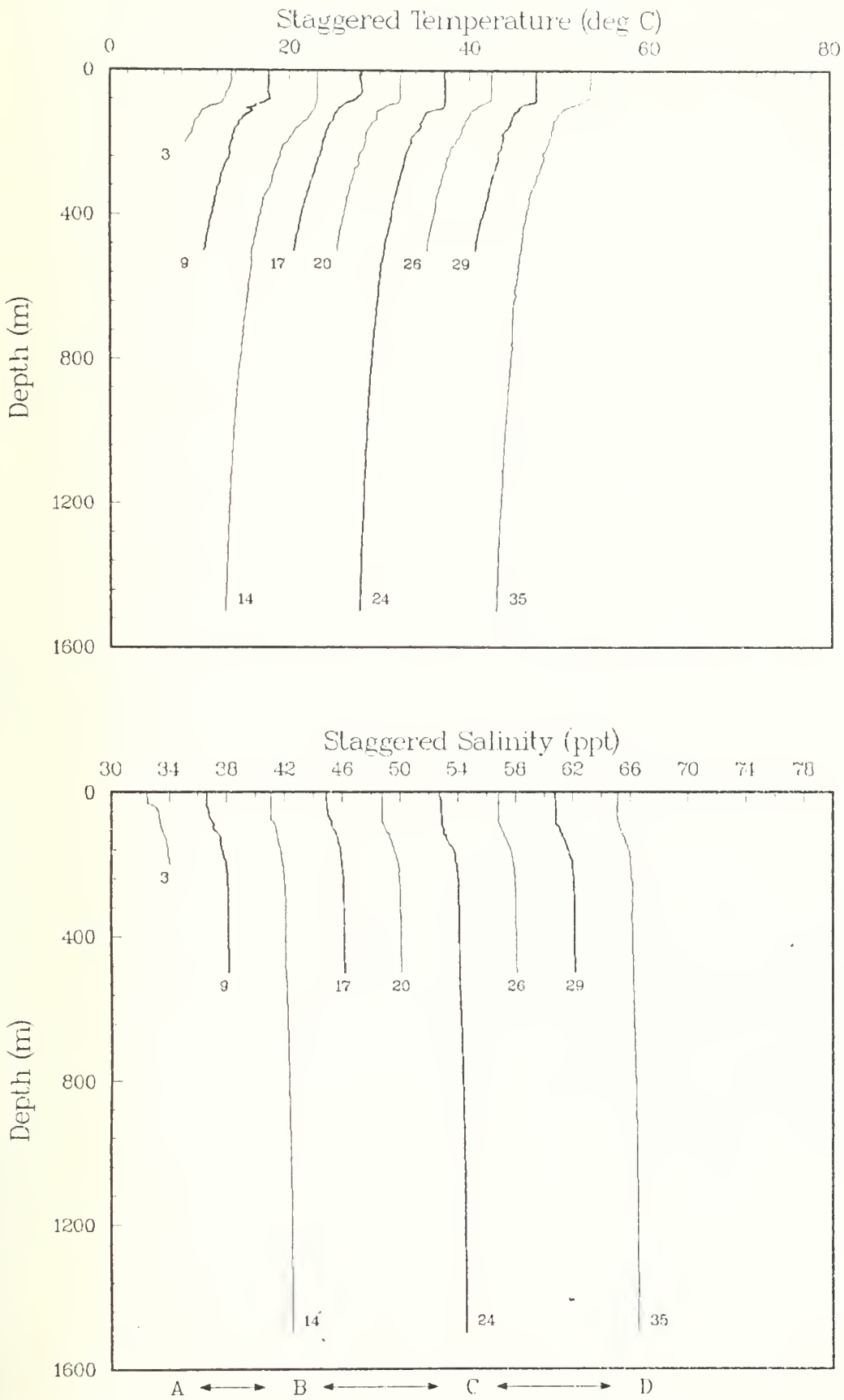
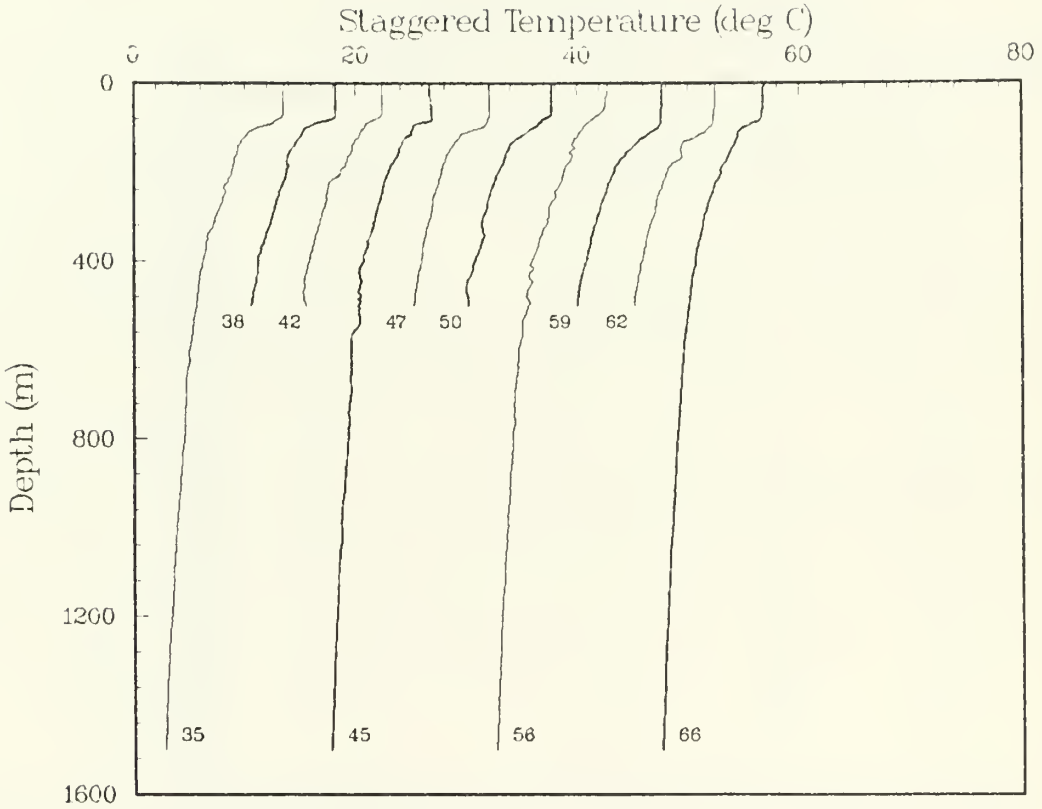



Figure 6(a): CTD temperature profiles, staggered by multiples of 5C, and salinity profiles, staggered by multiples of 4 ppt (OPTOMA4, Leg I).


Staggered Temperature (deg C)
0
20
40
60
80
0
400
800
1200
1600
Depth (m)
38
42
47
50
59
62
35
45
56
66

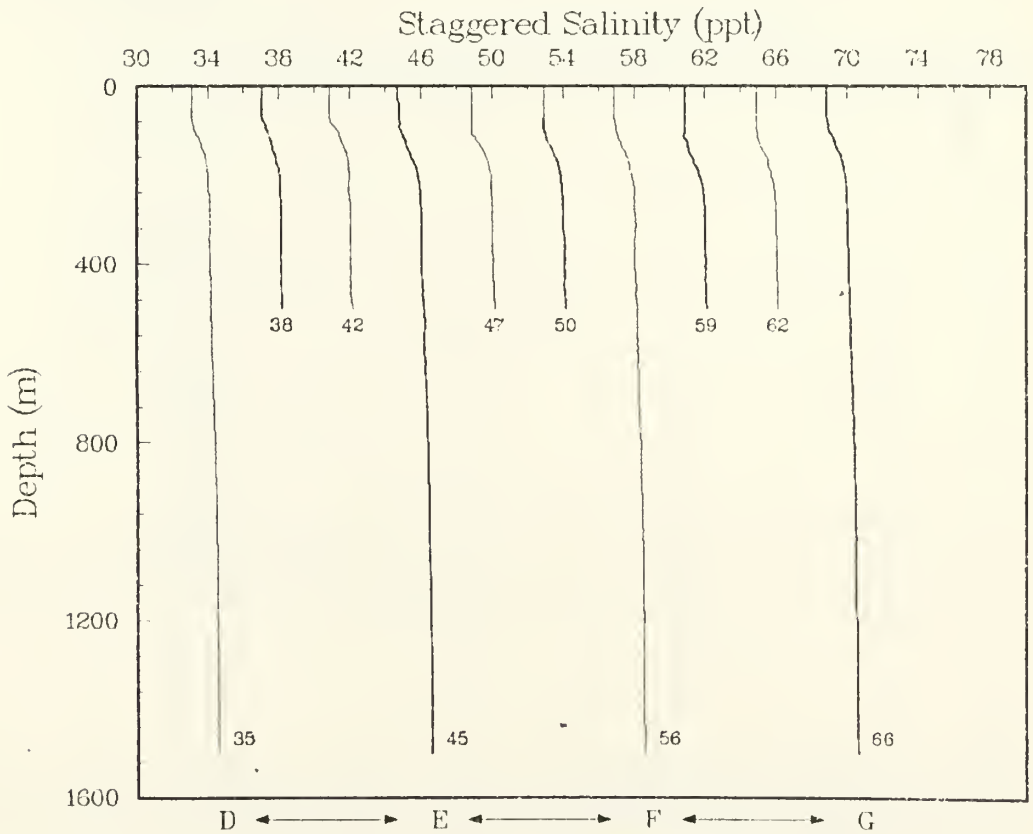

Staggered Salinity (ppt)
30
34
38
42
46
50
54
58
62
66
70
74
78
0
400
800
1200
1600
Depth (m)
38
42
47
50
59
62
35
45
56
66
D
E
F
G

Figure 6(b).

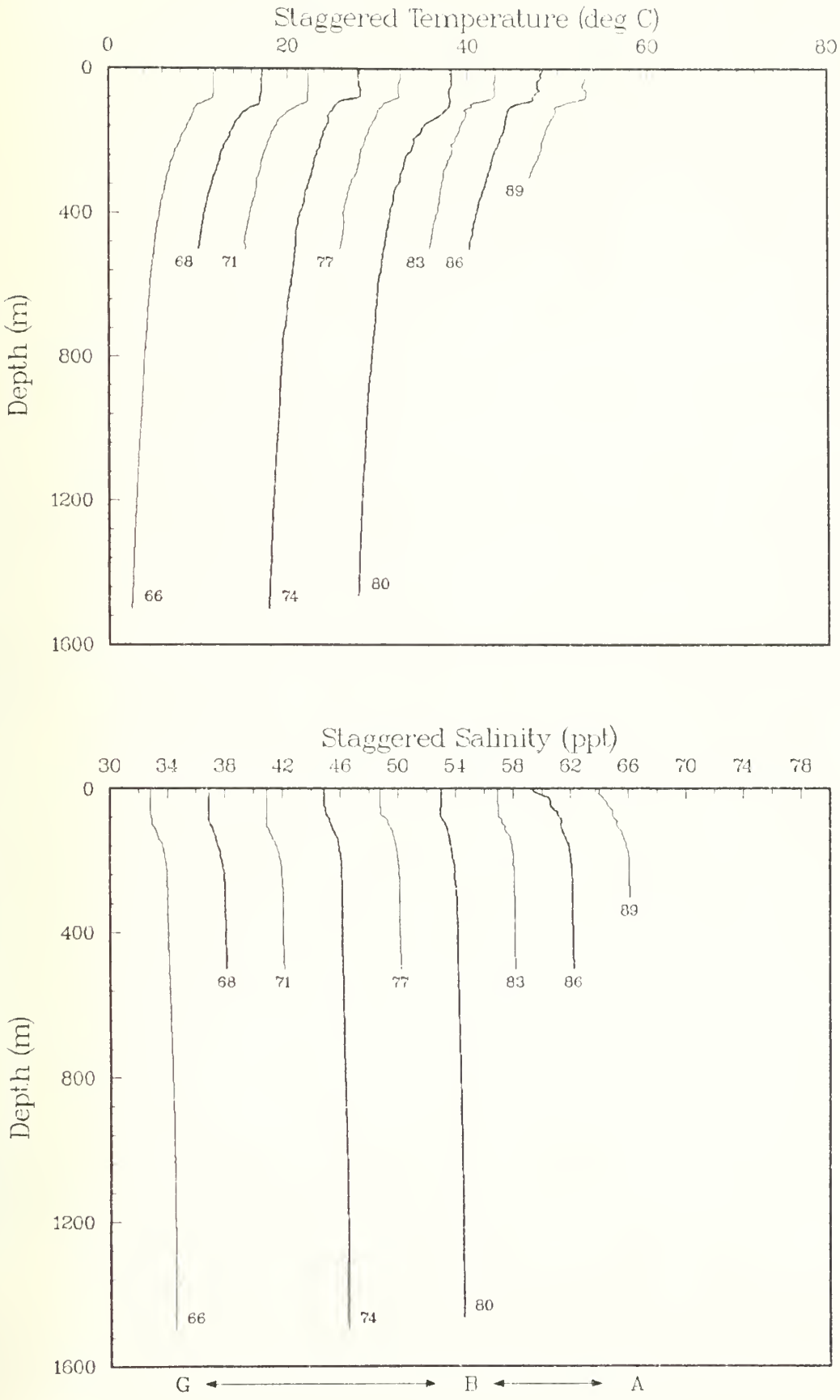

Staggered Temperature (deg C)
0
20
40
60
80
0
400
800
1200
1600
Depth (m)
68
71
77
83
86
89
66
74
80
Staggered Salinity (ppl)
30
34
38
42
46
50
54
58
62
66
70
74
78
0
400
800
1200
1600
Depth (m)
68
71
77
83
86
89
66
74
80
G
B
A

Figure 6(c).

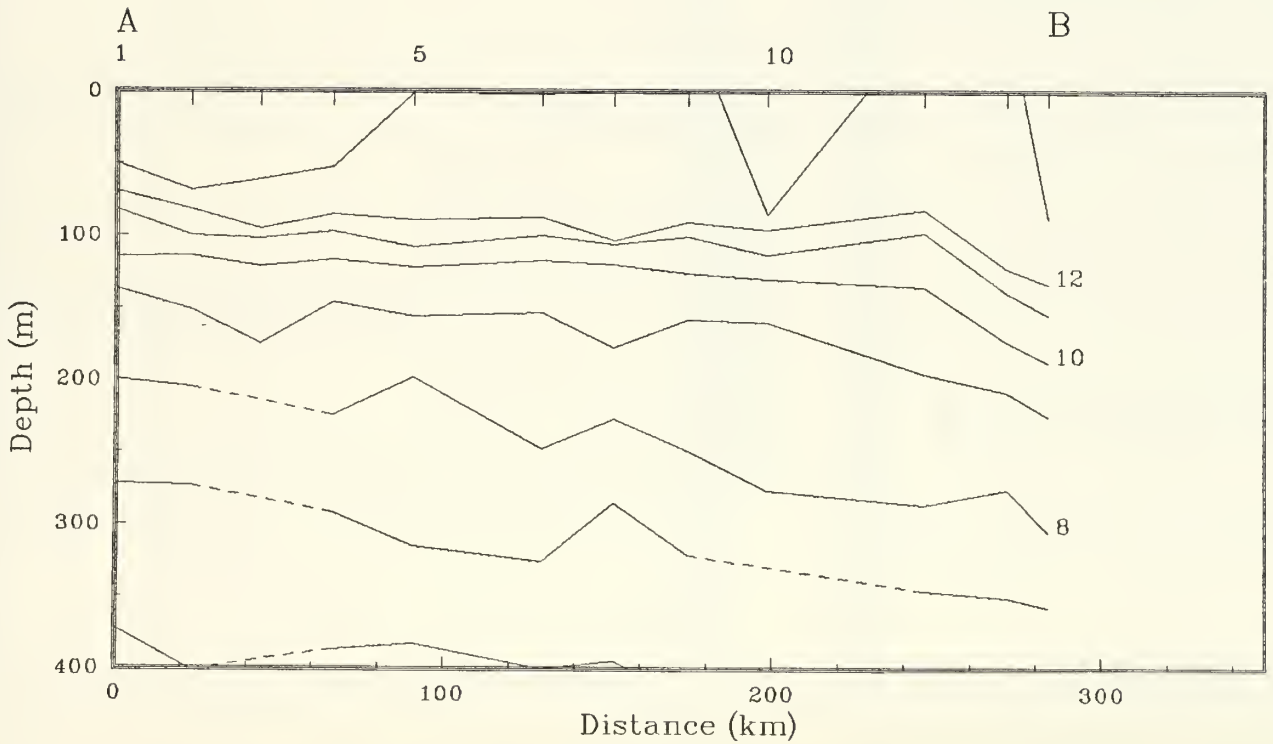



Figure 7(a): Isotherms from XBT's and CTD's. Tick marks along the upper horizontal axis show station positions. Some station numbers are given. Dashed lines are used if the cast was too shallow (OPTOMA4, Leg I).

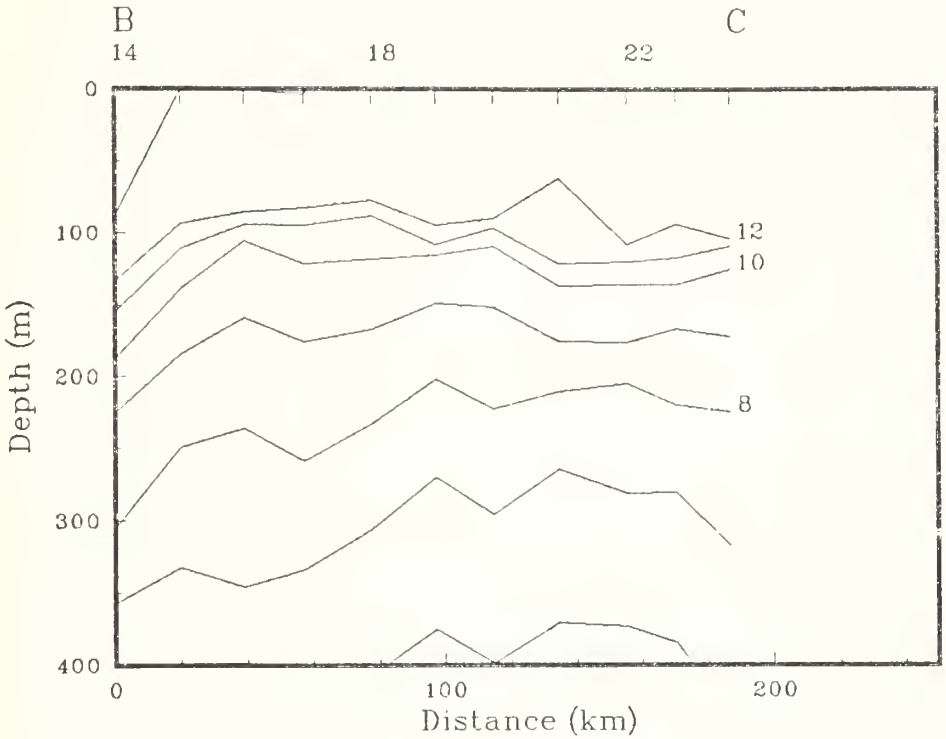



Figure 7(b)

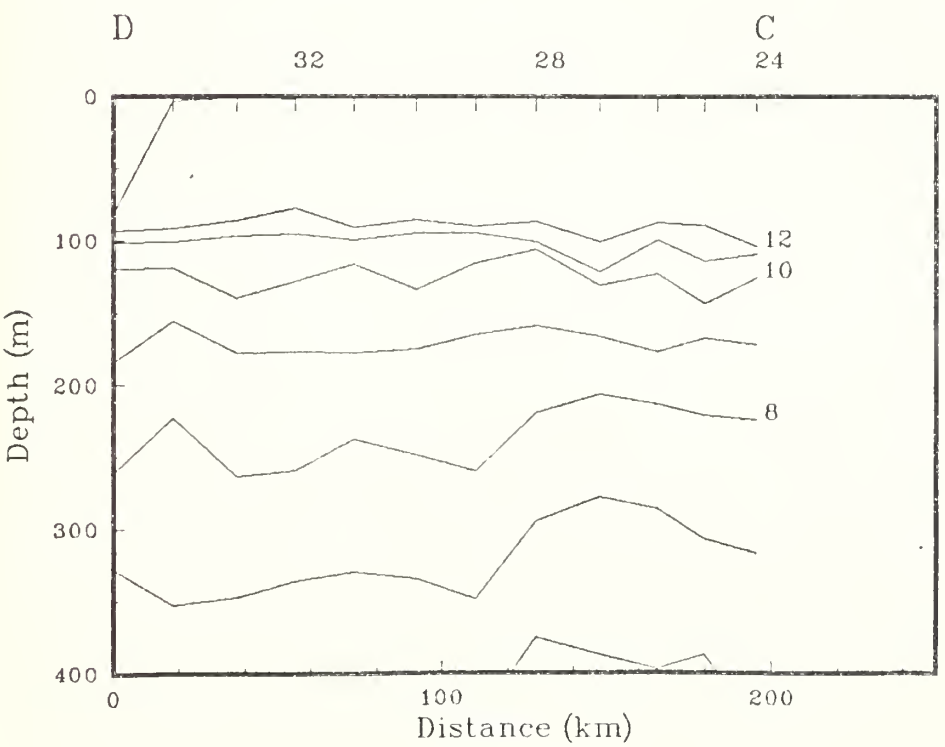



Figure 7(c)

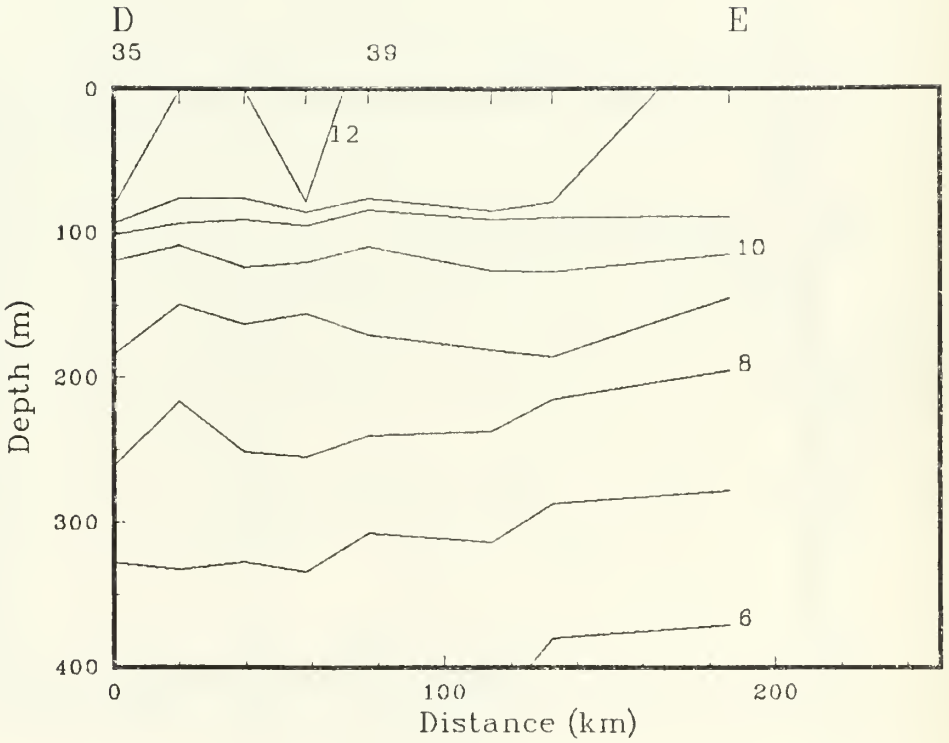



Figure 7(d)

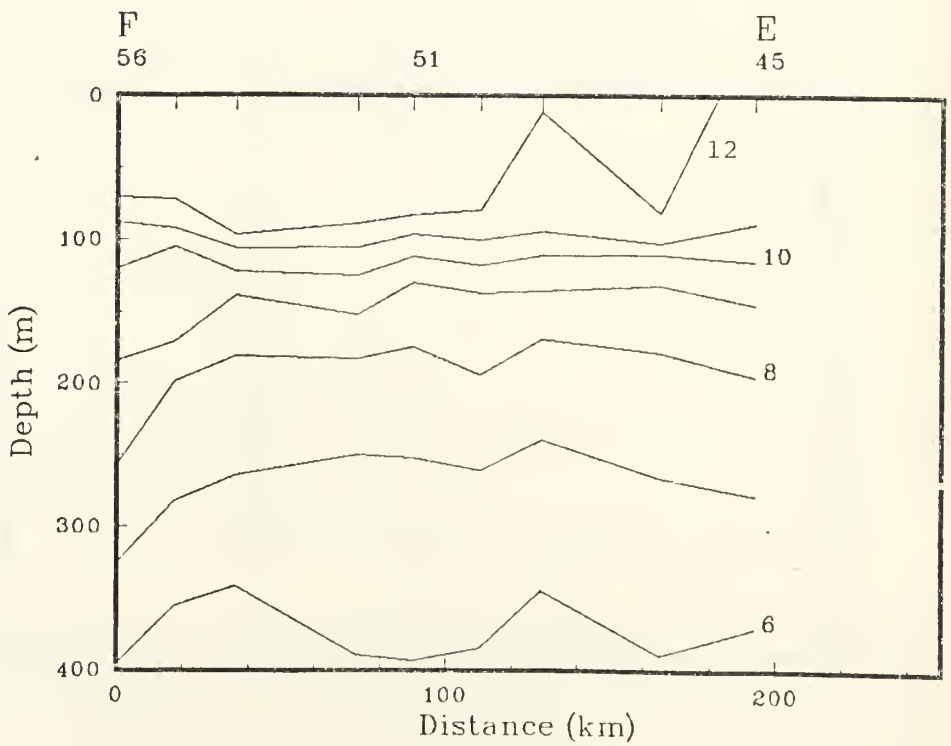



Figure 7(e)

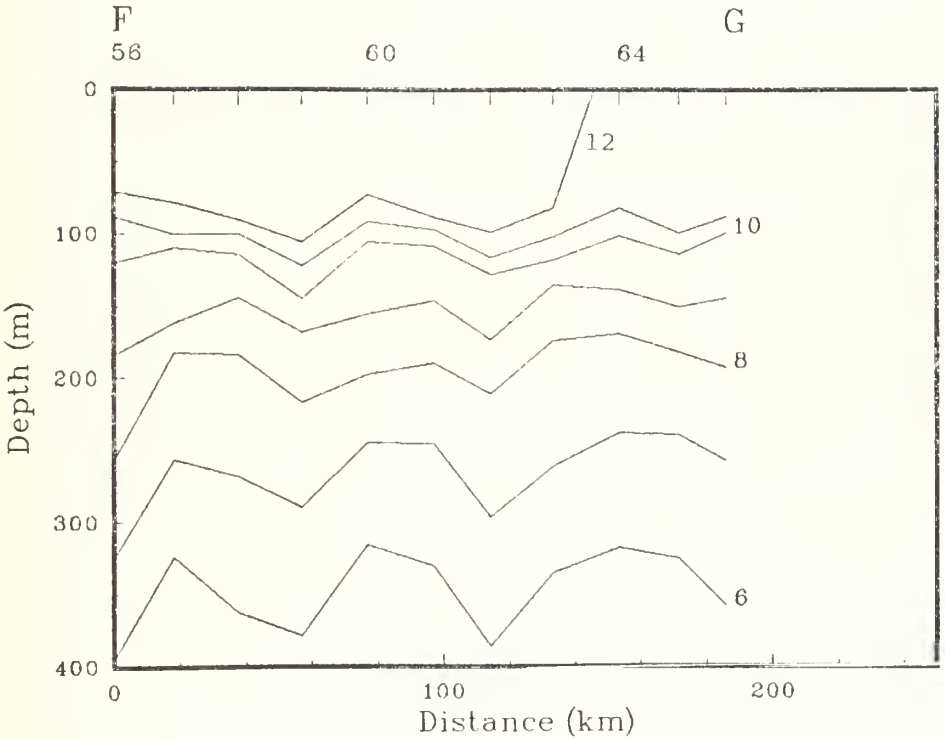

F
G
56
60
64
0
100
200
300
400
Depth (m)
12
10
8
6
0
100
200
Distance (km)

Figure 7(f)

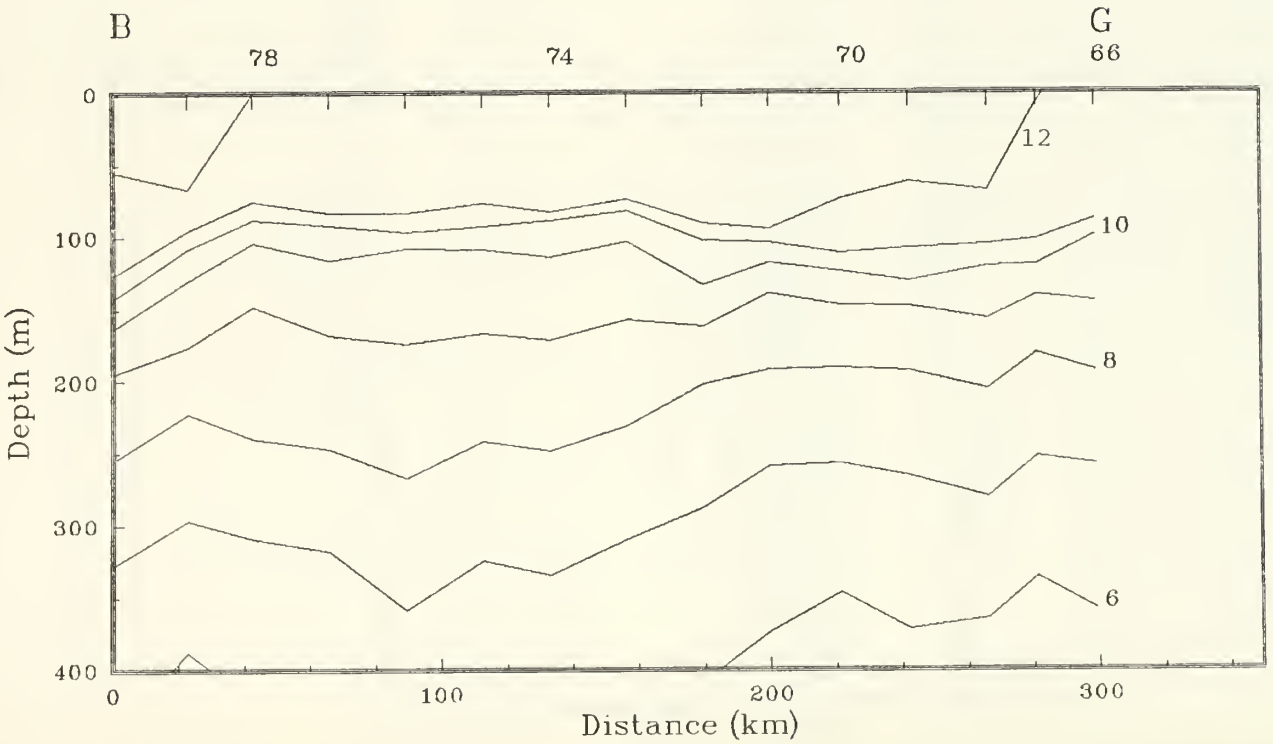

B
G
78
74
70
66
0
100
200
300
400
Depth (m)
12
10
8
6
0
100
200
300
Distance (km)

Figure 7(g)

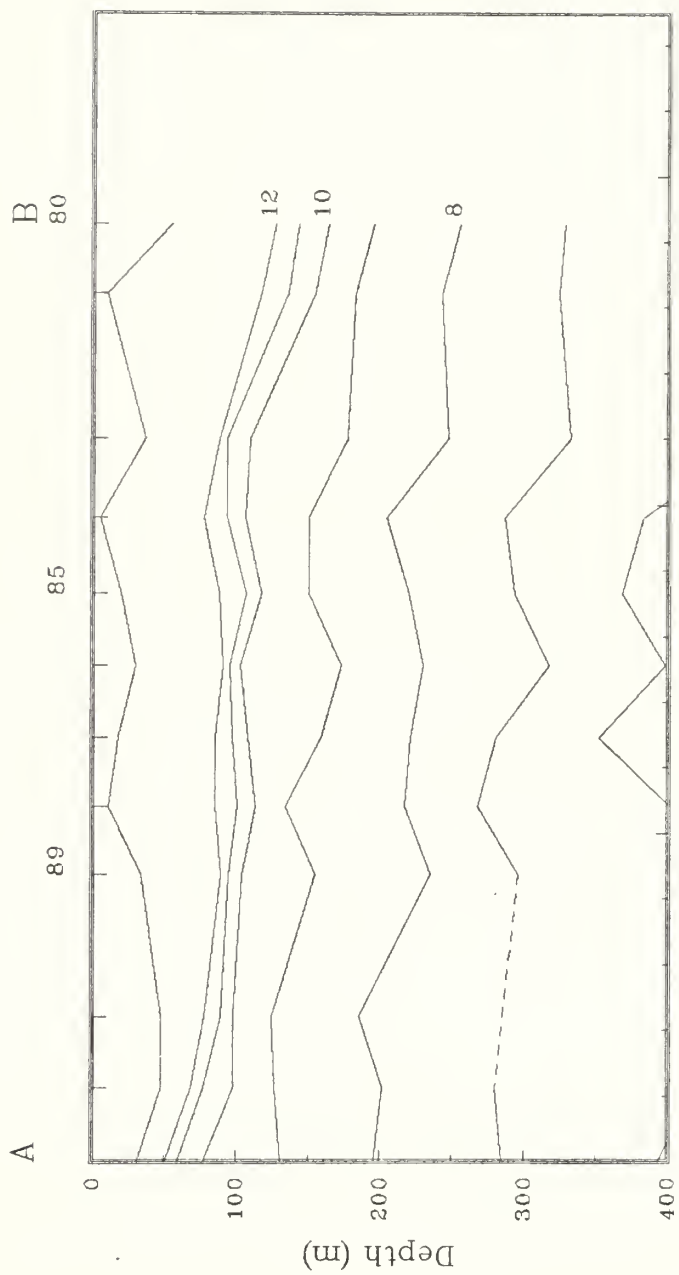

A
B
89
85
80
12
10
8
0
100
200
300
400
Depth (m)
0
100
200
300
Distance (km)

Figure 7(h)

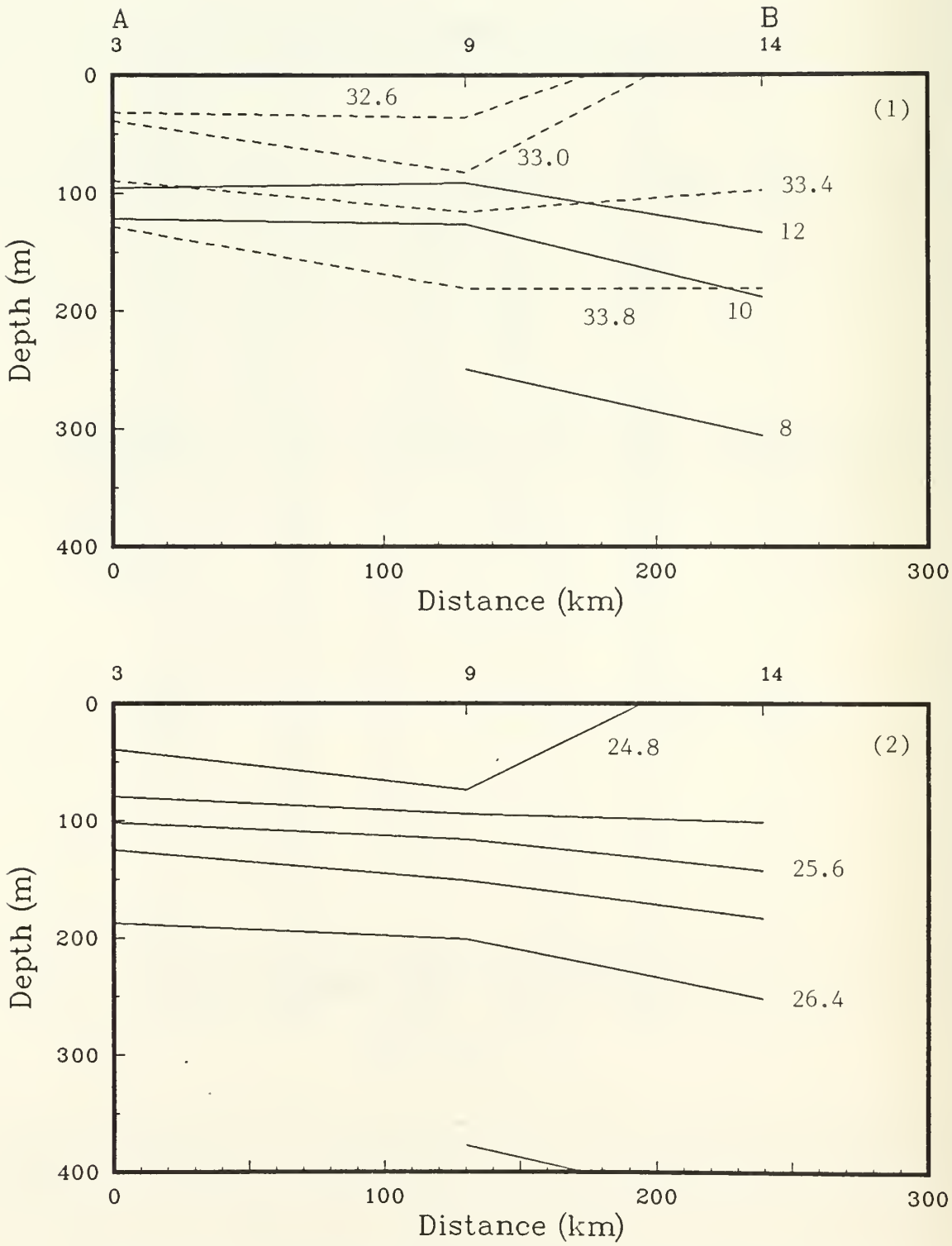



Figure 8(a): Isopleths of (1) temperature and salinity and (2) sigma-t from the CTD's (OPTOMA4, Leg I).

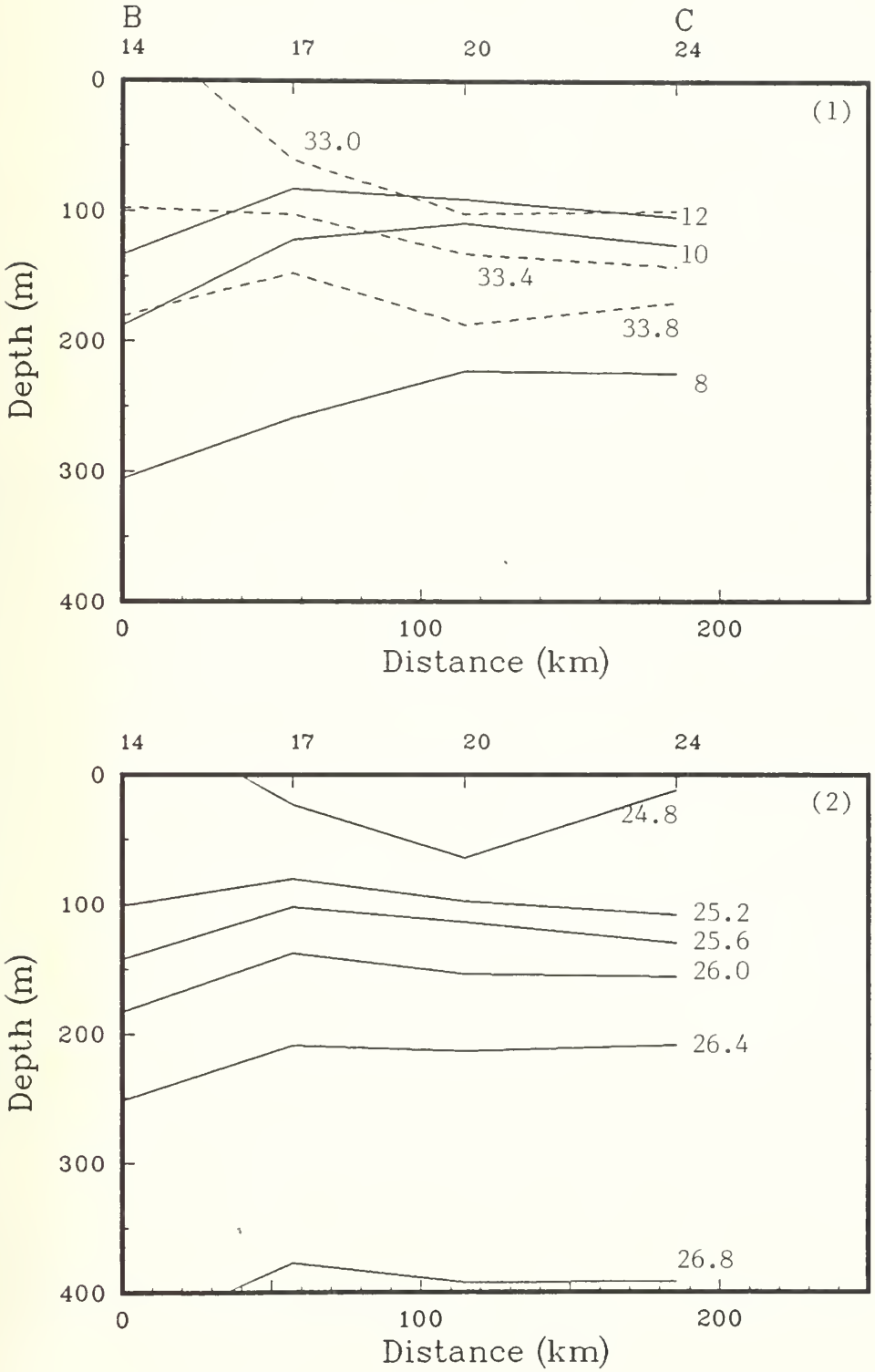
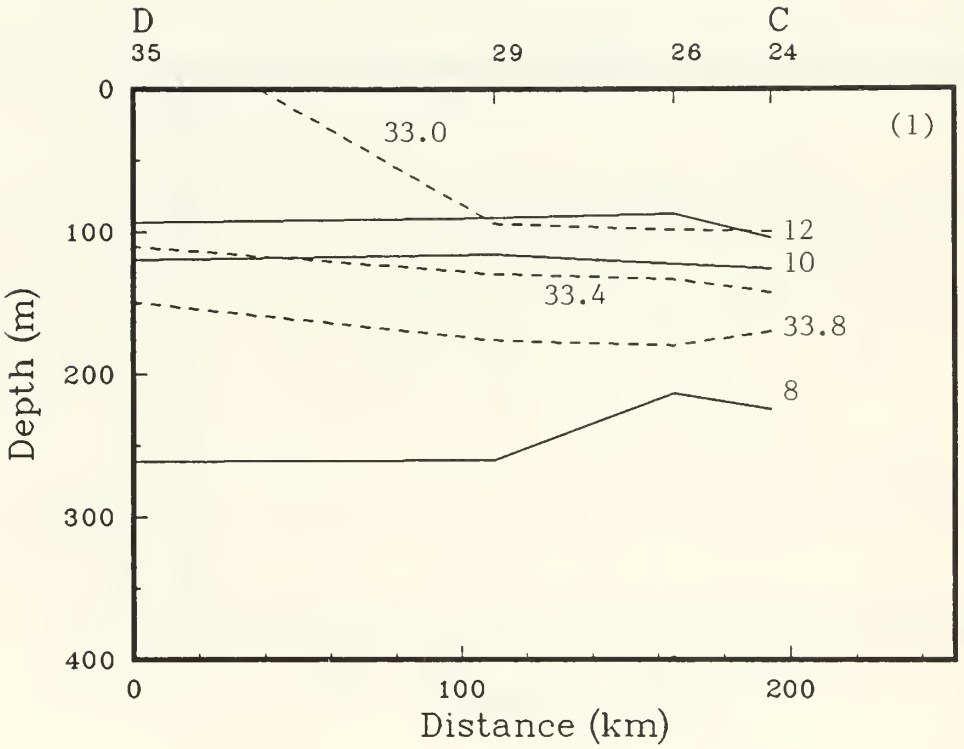

B
C
14
17
20
24
0
100
200
300
400
Depth (m)
(1)
33.0
12
10
33.4
33.8
8
0
100
200
Distance (km)
14
17
20
24
0
100
200
300
400
Depth (m)
(2)
24.8
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 8(b)


D
C
35
29
26
24
0
100
200
300
400
Depth (m)
33.0
(1)
12
10
33.4
33.8
8
0
100
200
Distance (km)

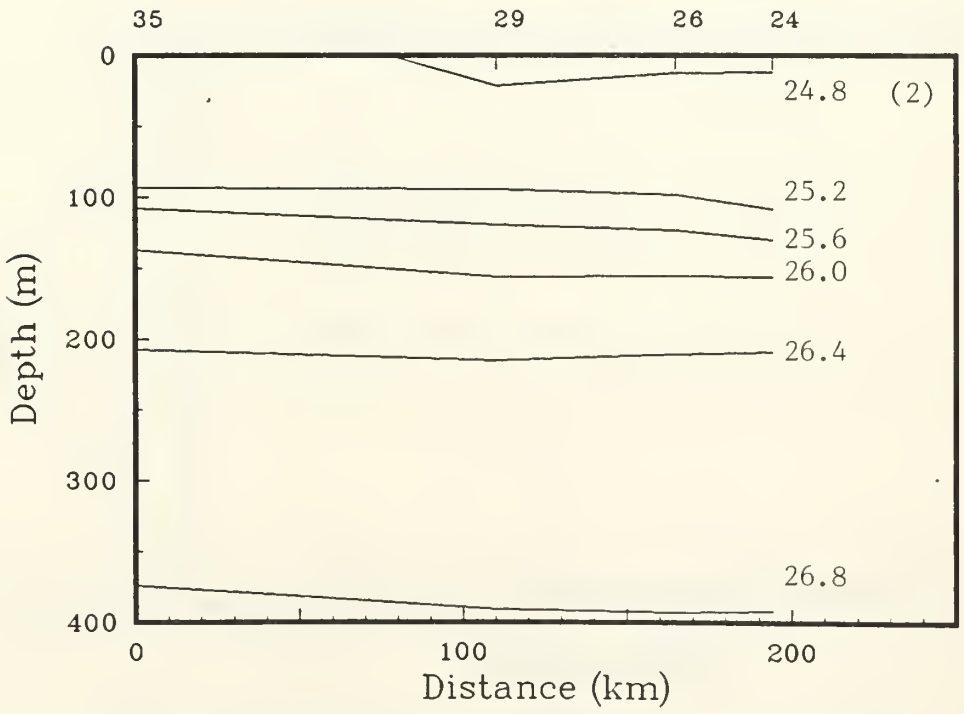

35
29
26
24
0
100
200
300
400
Depth (m)
24.8
(2)
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 8(c)

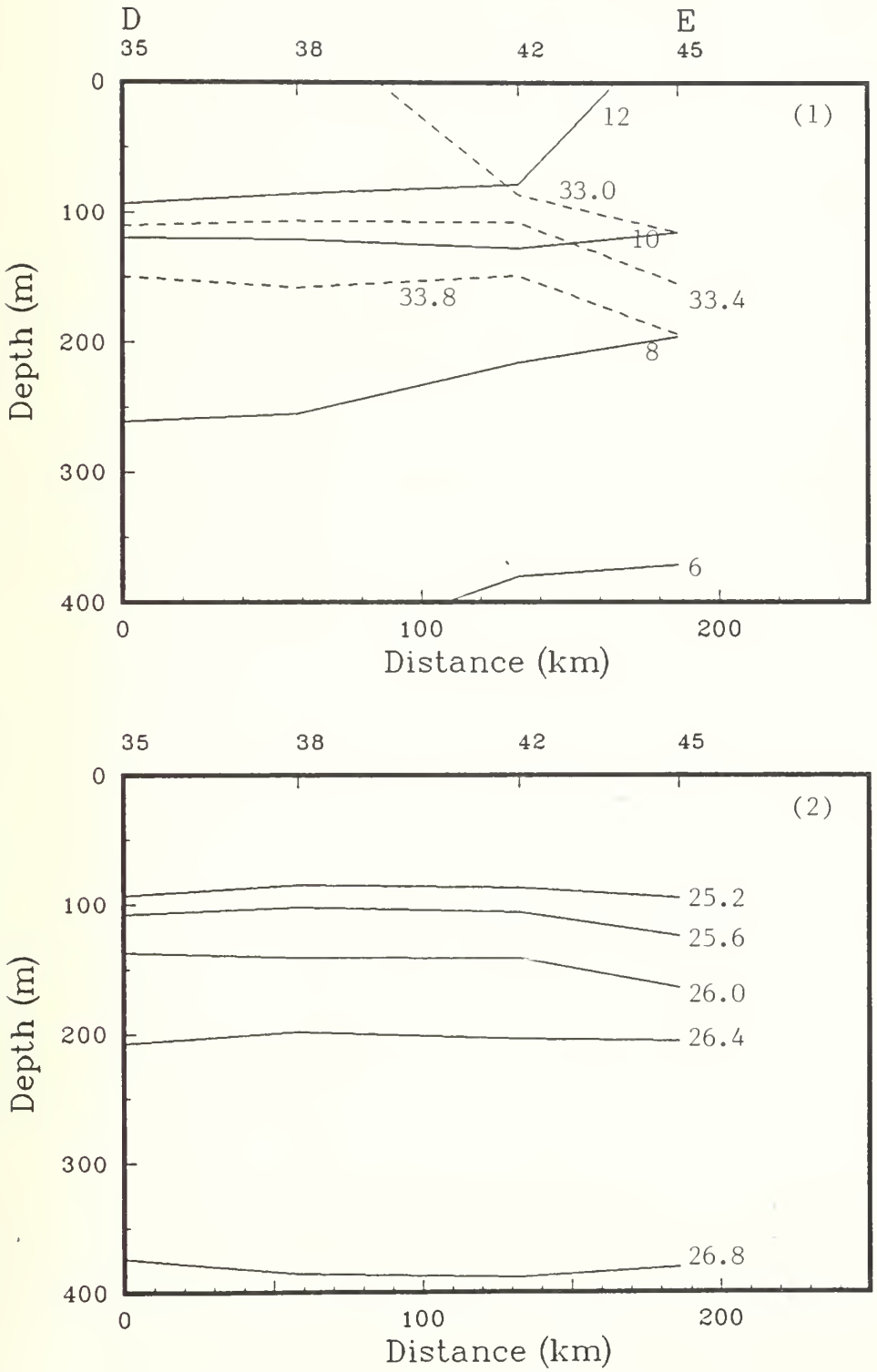

D
E
35
38
42
45
0
100
200
300
400
Depth (m)
12
(1)
33.0
10
33.8
33.4
8
6
0
100
200
Distance (km)
35
38
42
45
0
100
200
300
400
Depth (m)
(2)
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 8(d)

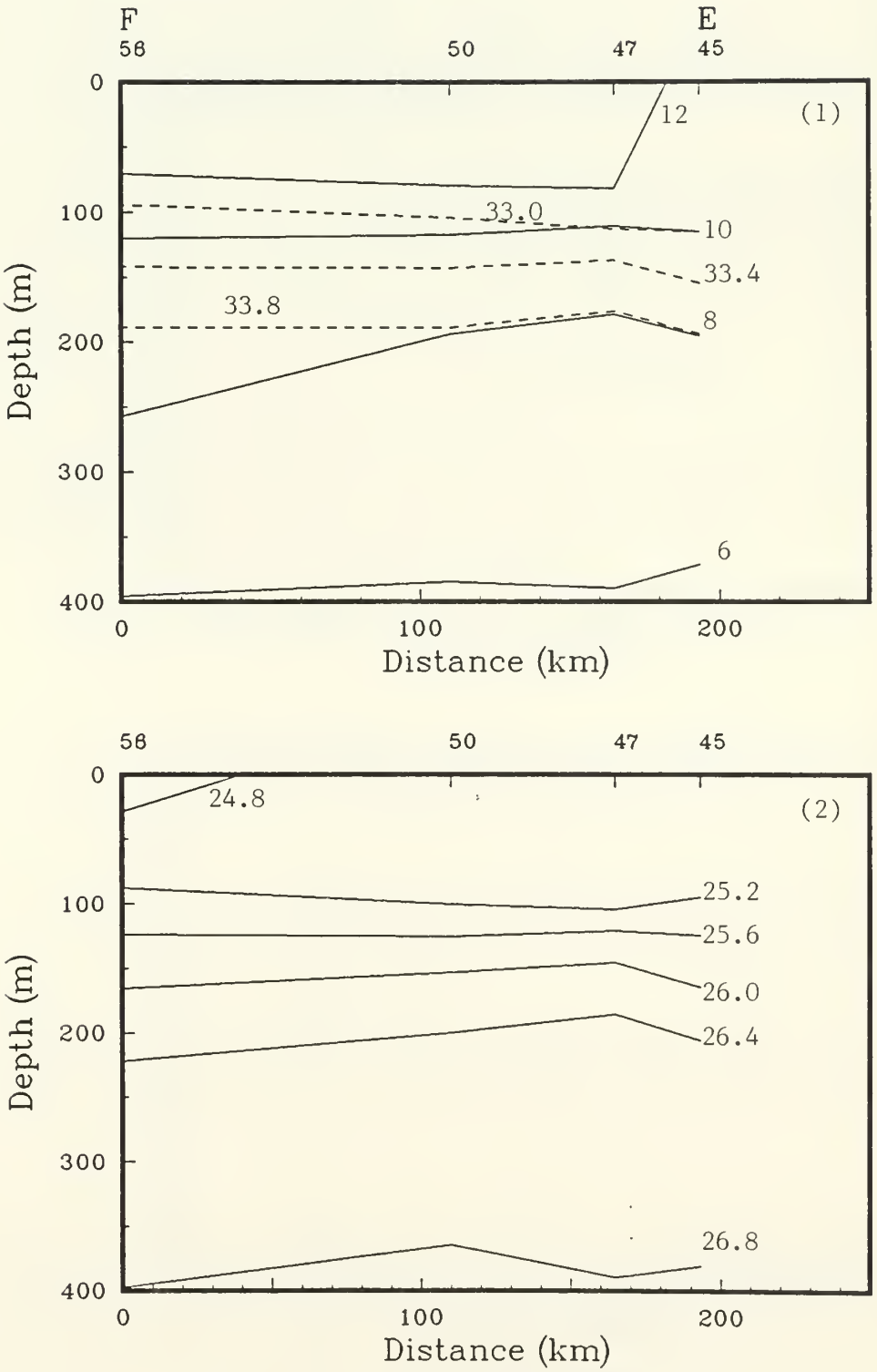

F
E
58
50
47
45
0
100
200
300
400
Depth (m)
12
(1)
33.0
10
33.4
33.8
8
6
0
100
200
Distance (km)
58
50
47
45
0
100
200
300
400
Depth (m)
24.8
(2)
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 8(e)

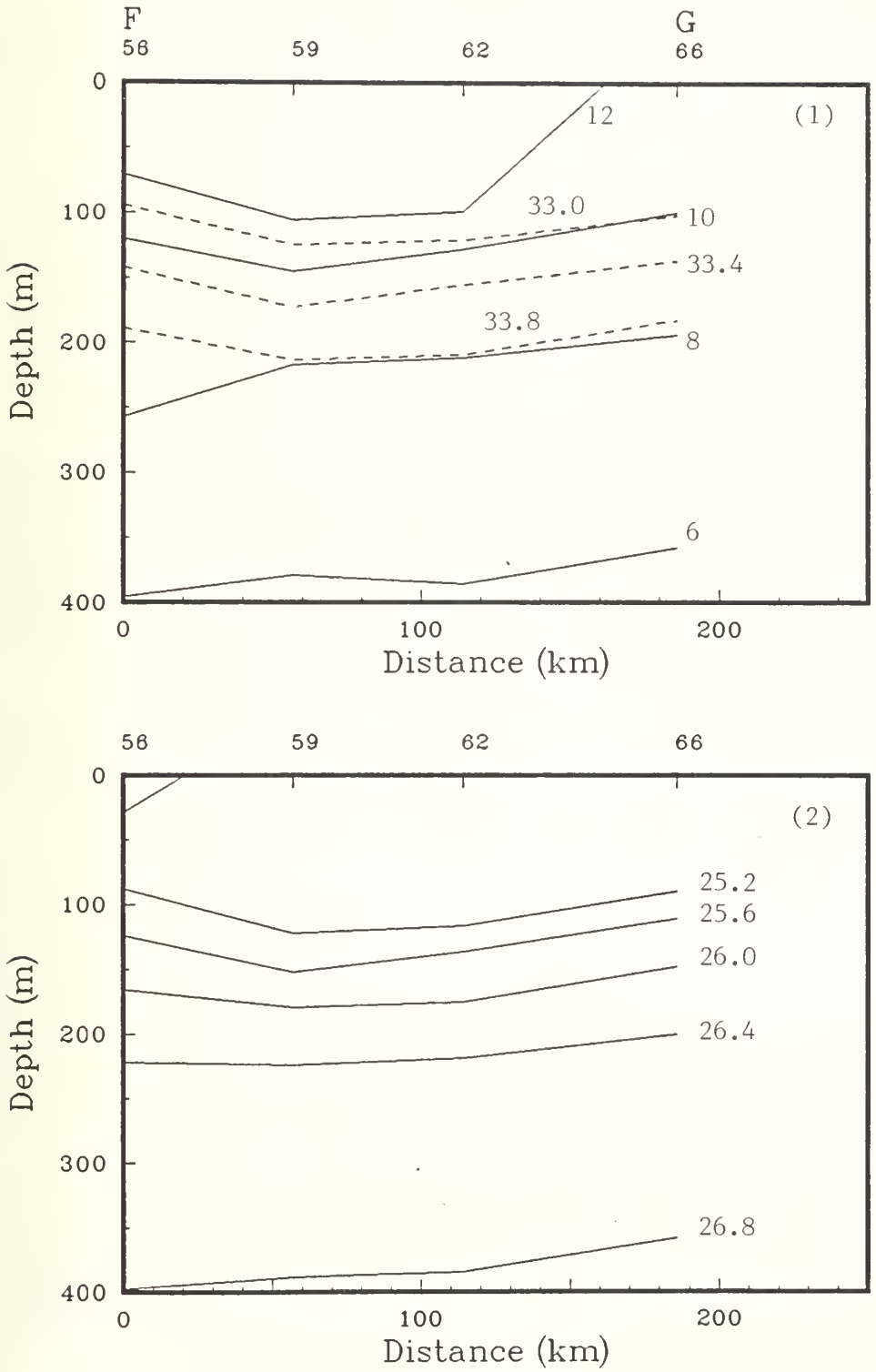

F
G
56
59
62
66
0
100
200
300
400
Depth (m)
12
(1)
33.0
10
33.4
33.8
8
6
0
100
200
Distance (km)
56
59
62
66
0
100
200
300
400
Depth (m)
(2)
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 8(f)

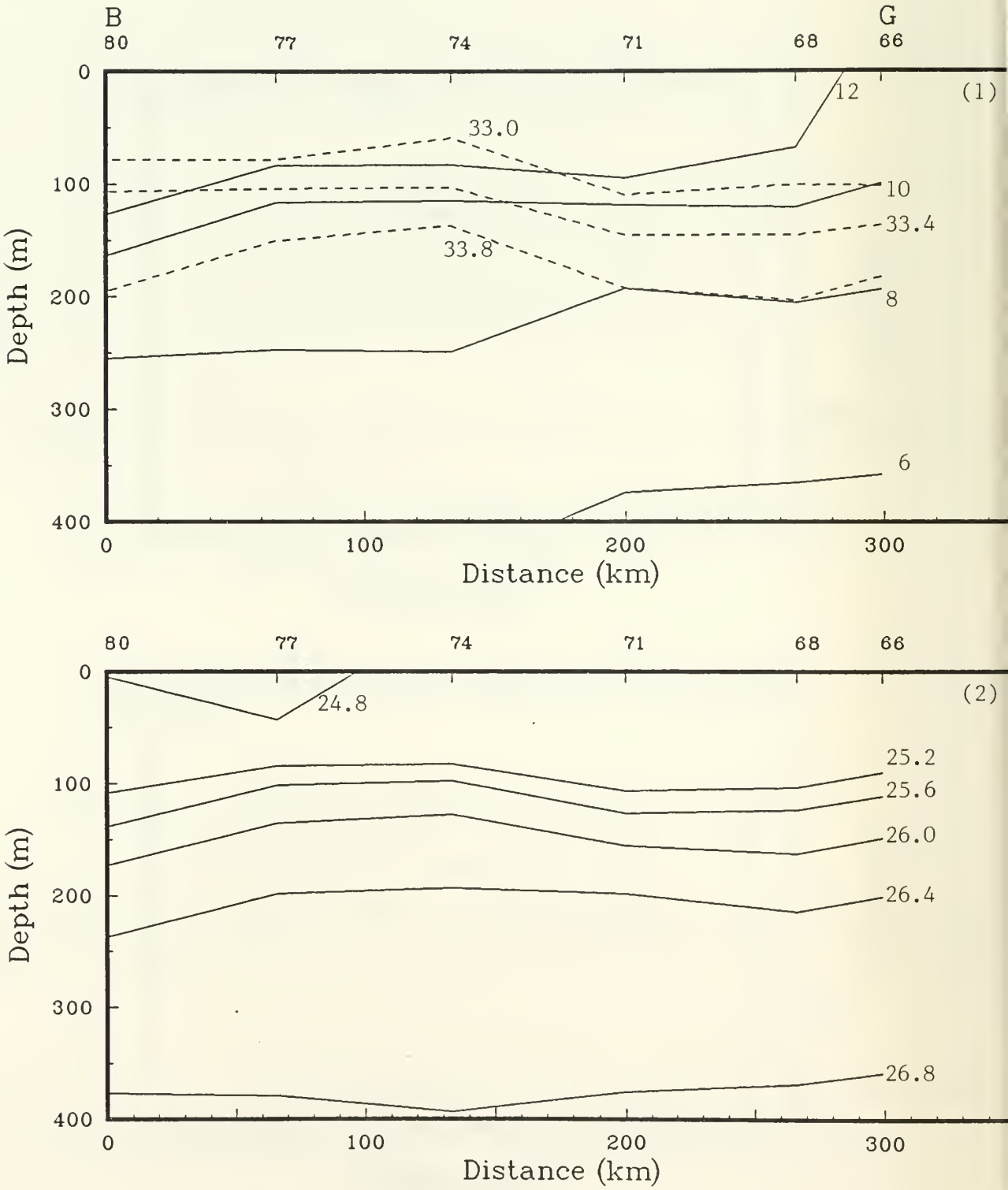

B
G
80
77
74
71
68
66
0
100
200
300
400
Depth (m)
(1)
12
33.0
10
33.4
33.8
8
6
0
100
200
300
Distance (km)
80
77
74
71
68
66
0
100
200
300
400
Depth (m)
(2)
24.8
25.2
25.6
26.0
26.4
26.8
0
100
200
300
Distance (km)

Figure 8(g)

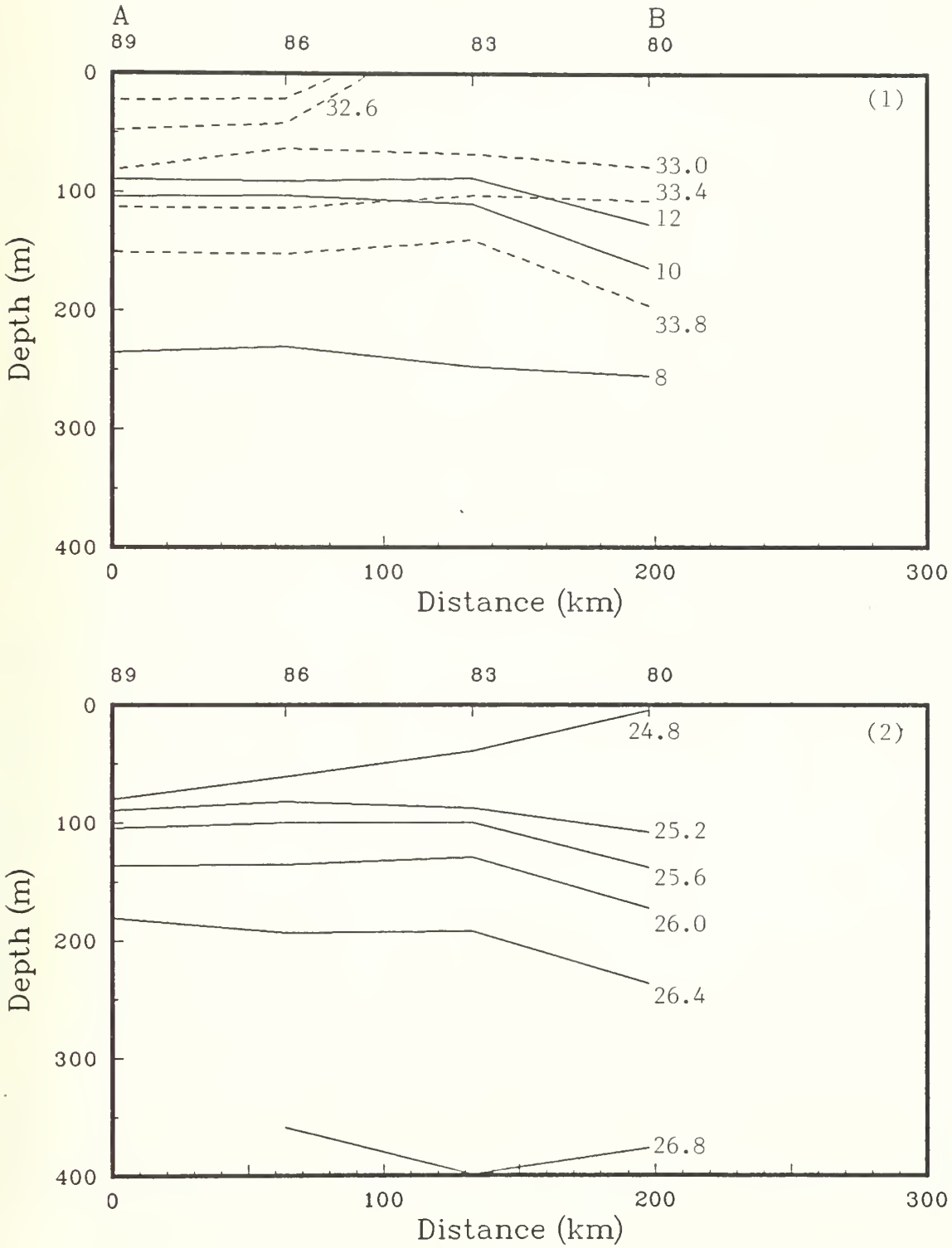

A
B
89
86
83
80
(1)
32.6
33.0
33.4
12
10
33.8
8
Depth (m)
0
100
200
300
400
0
100
200
300
Distance (km)
89
86
83
80
(2)
24.8
25.2
25.6
26.0
26.4
26.8
Depth (m)
0
100
200
300
400
0
100
200
300
Distance (km)

Figure 8(h)

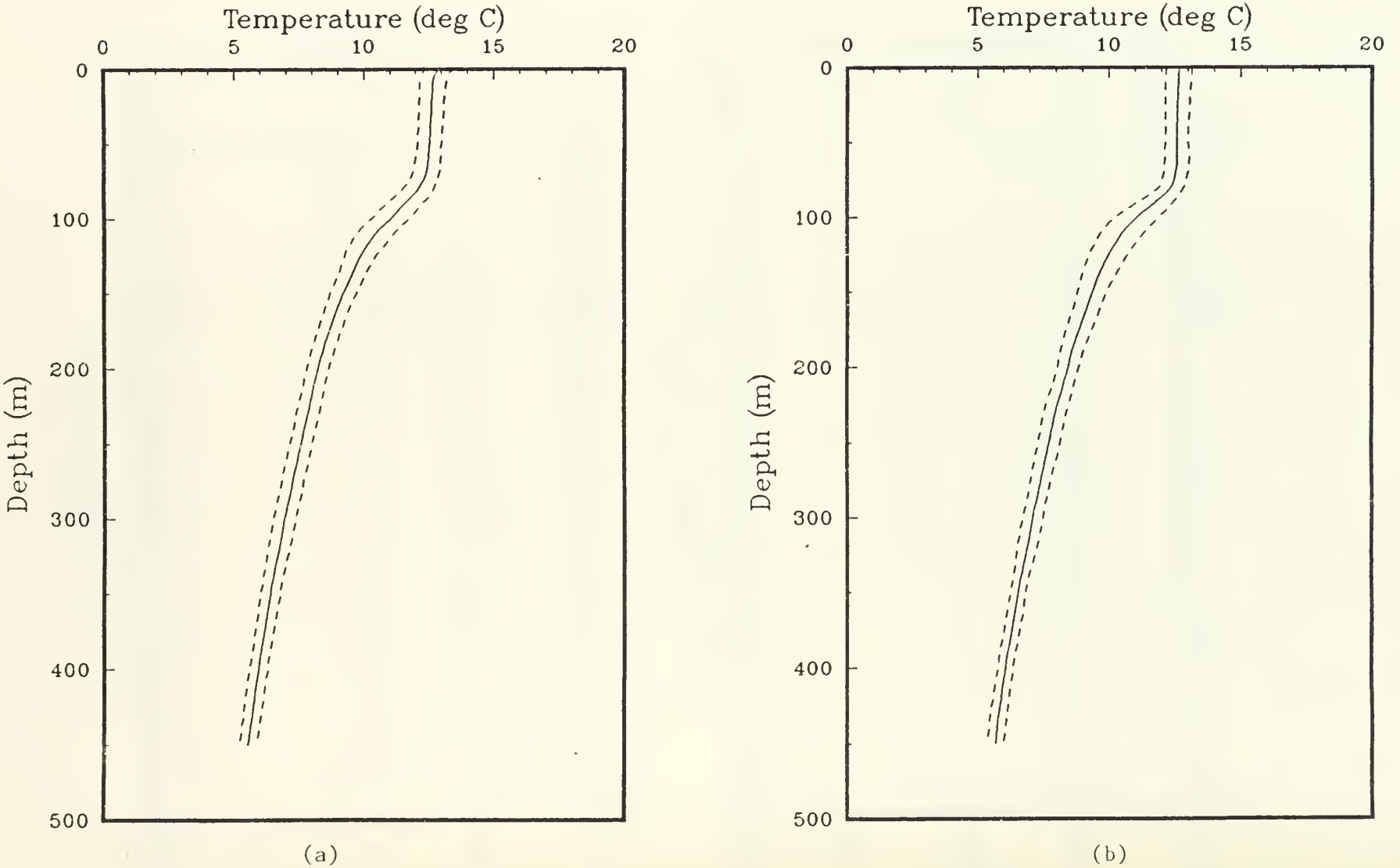



Figure 9 : Profiles of $\overline{T(z)}$ with + and - the standard deviation from (a) XBT's and (b) CTD's (OPTOMA4, Leg I).

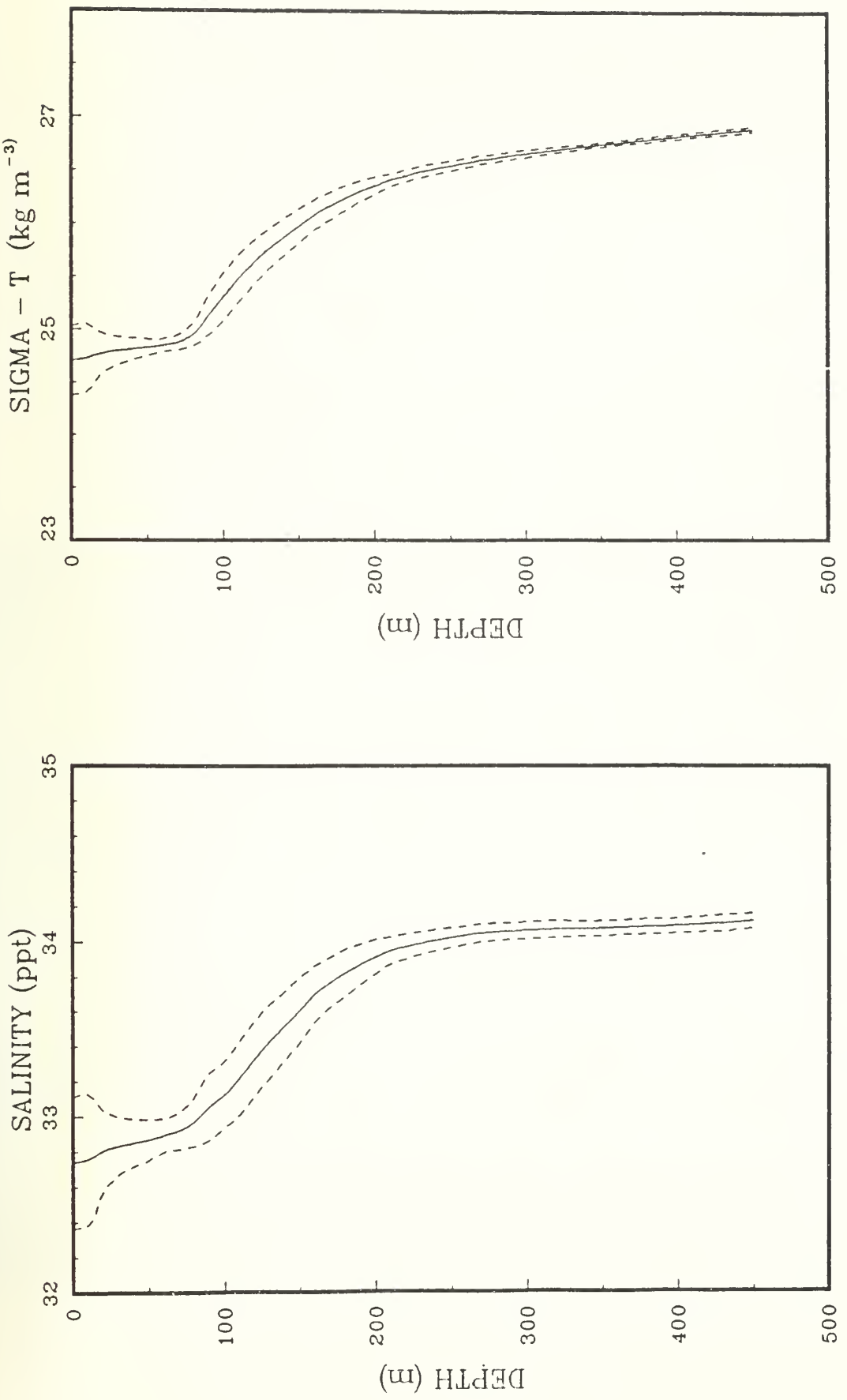



Figure 10: Profiles of (a) mean salintiy and (b) mean sigma-t, with + and - the standard deviations, from the CTD's (OPTOMA4, Leg I).

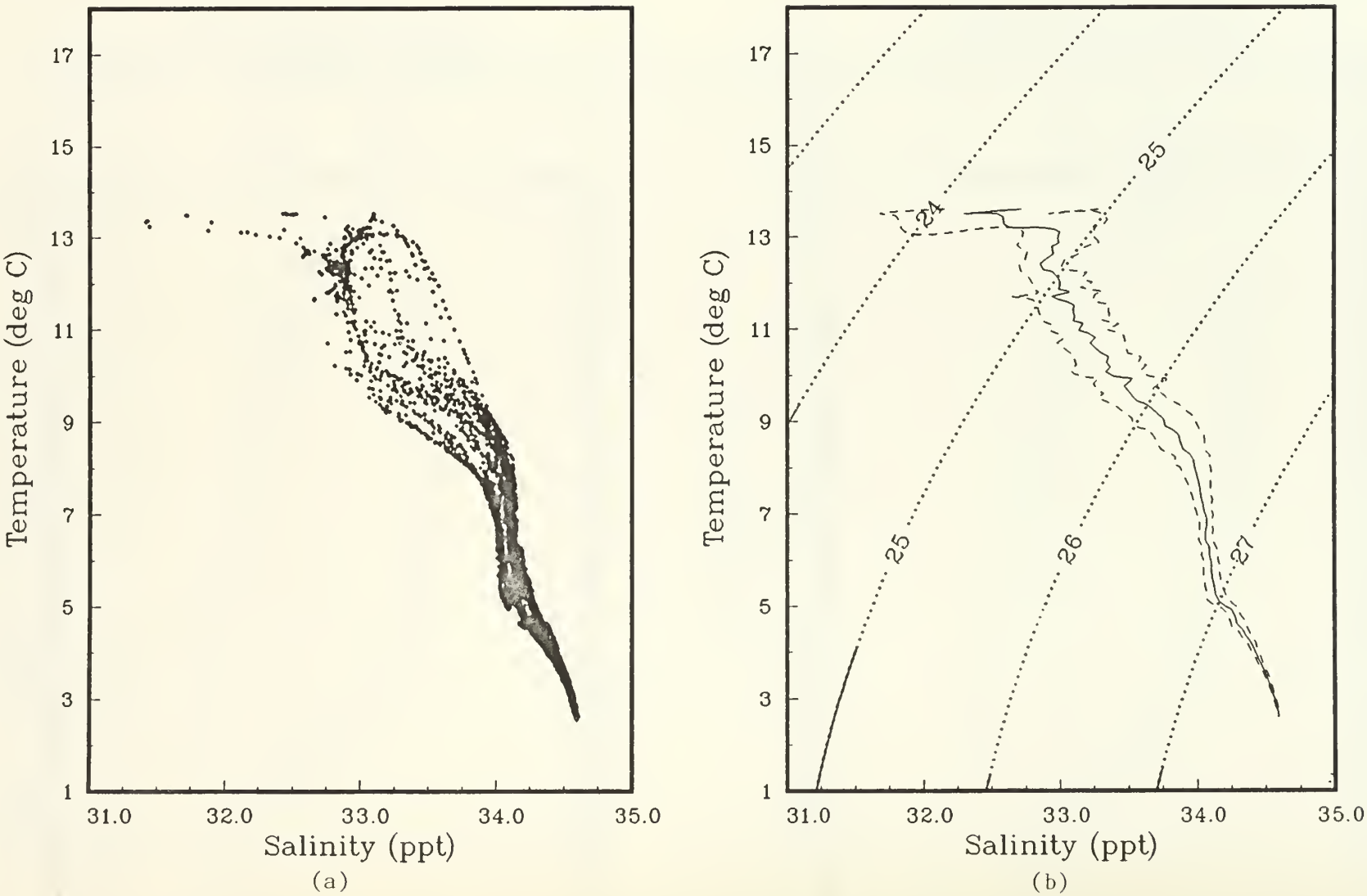



Figure 11: (a) T-S pairs and (b) mean T-S relationship, with + and - the standard deviation, and selected sigma-t contours, from the CTD casts (OPTOMA4, Leg I).

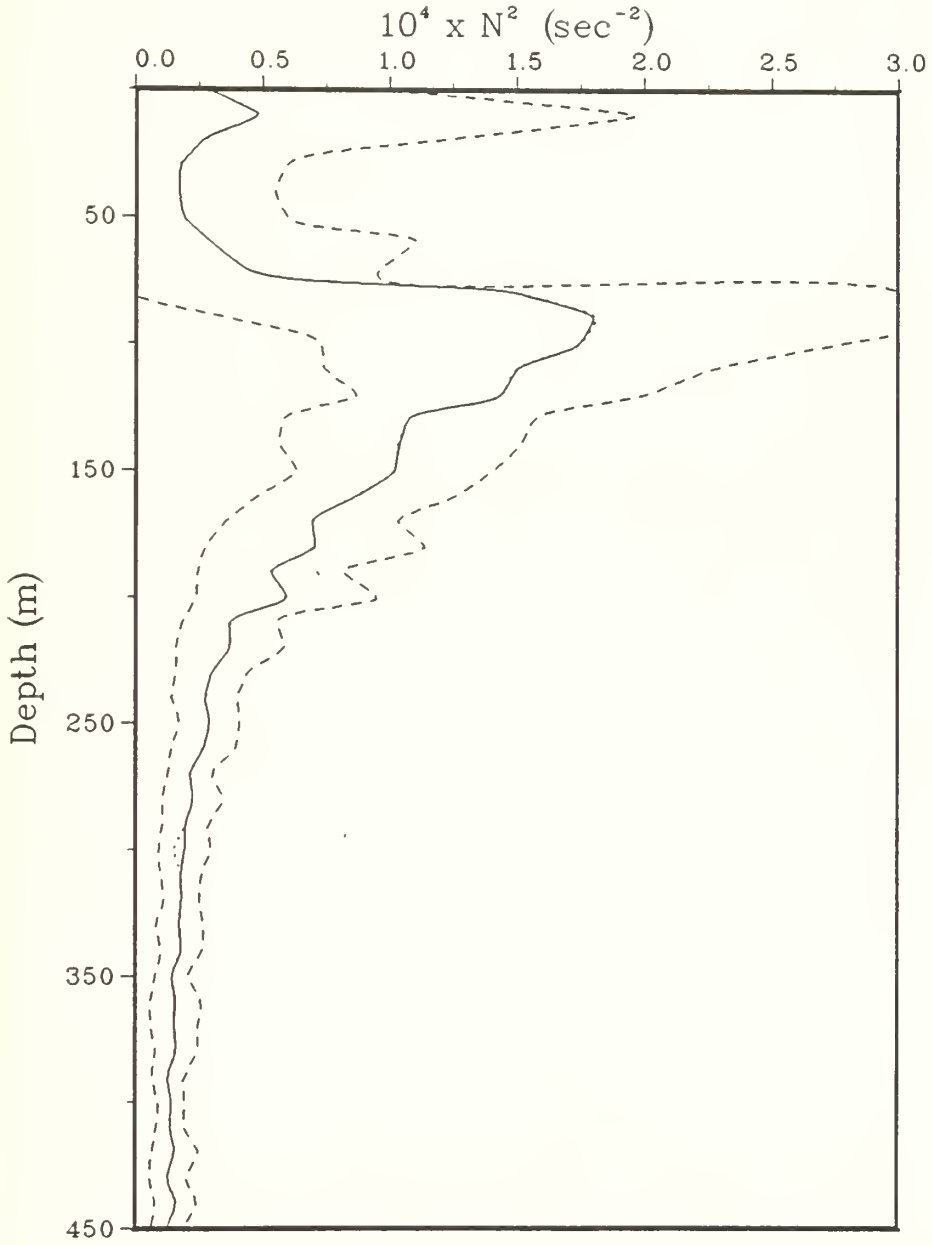



Figure 12: Profile of $\overline{N^2(z)}$ (_____), with + and - the standard deviation (---), and the profile of $N^2$ from $\overline{T(z)}$ and $\overline{S(z)}$ (...) (OPTOMA4, Leg I).

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# SECTION 2

## OPTOMA4 Leg II

## 5 - 10 April 1983

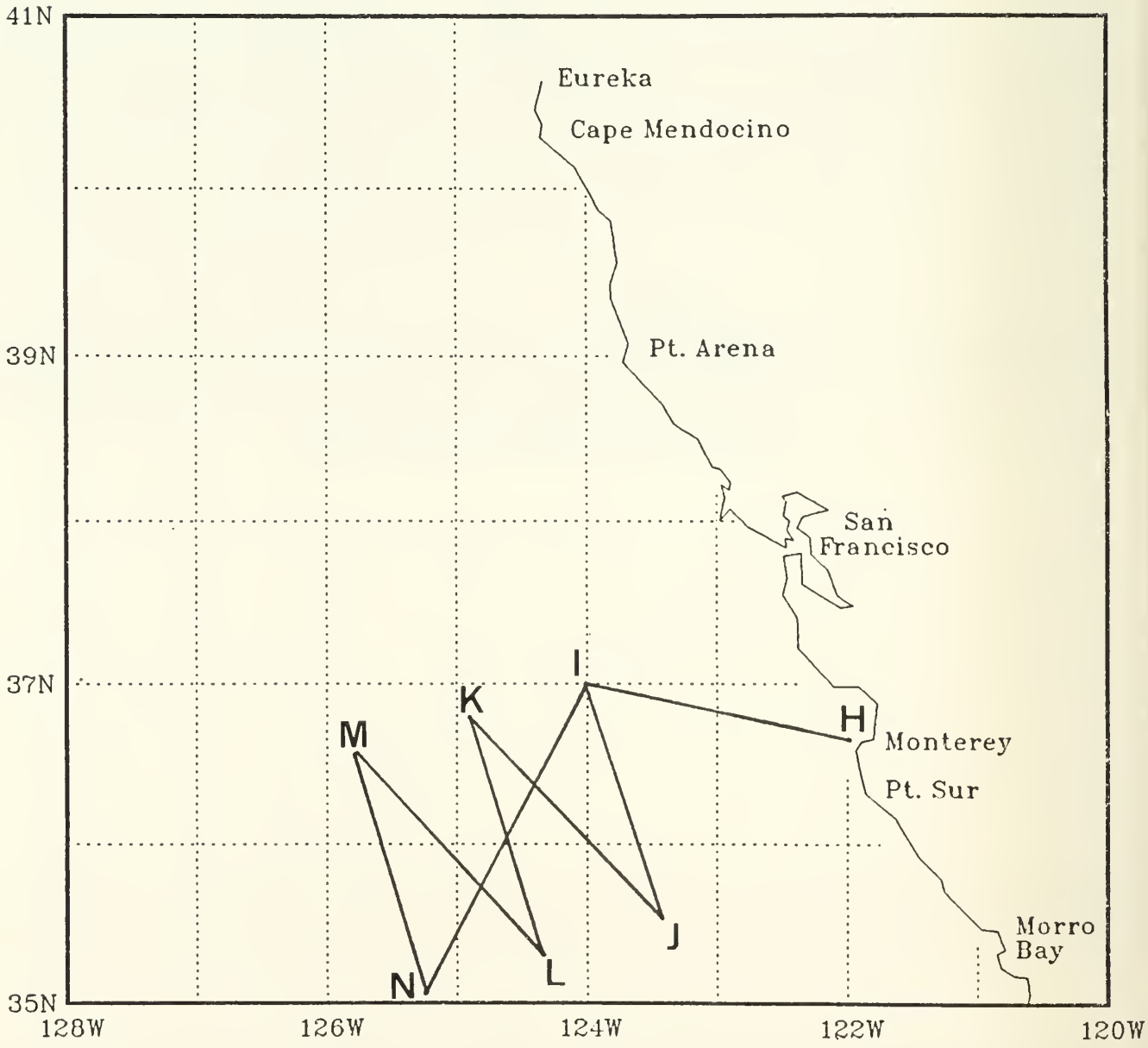



Figure 13: Cruise track for OPTOMA4, Leg II with transect extremes identified by letter.

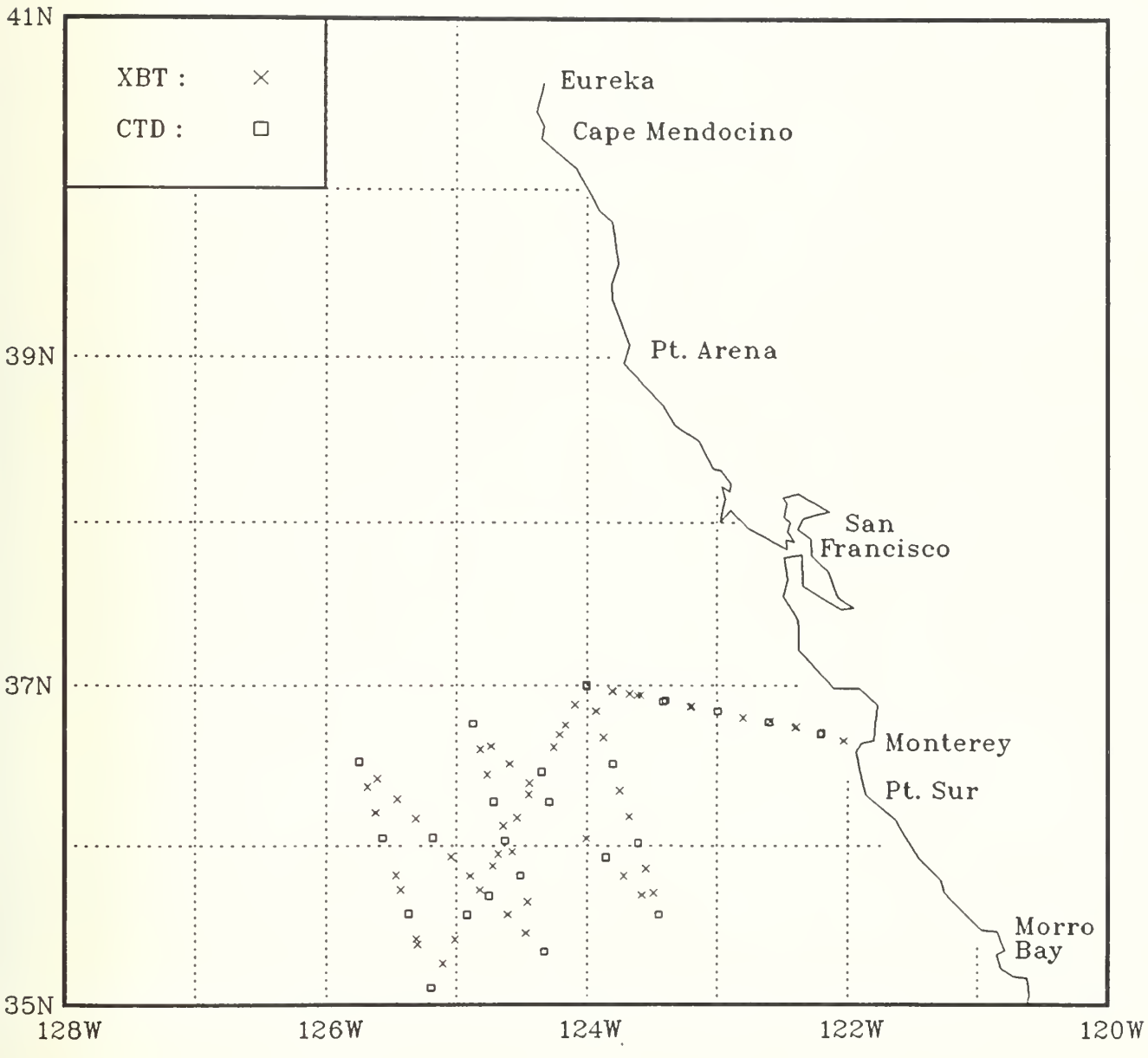



Figure 14: XBT and CTD locations for OPTOMA4, Leg II.

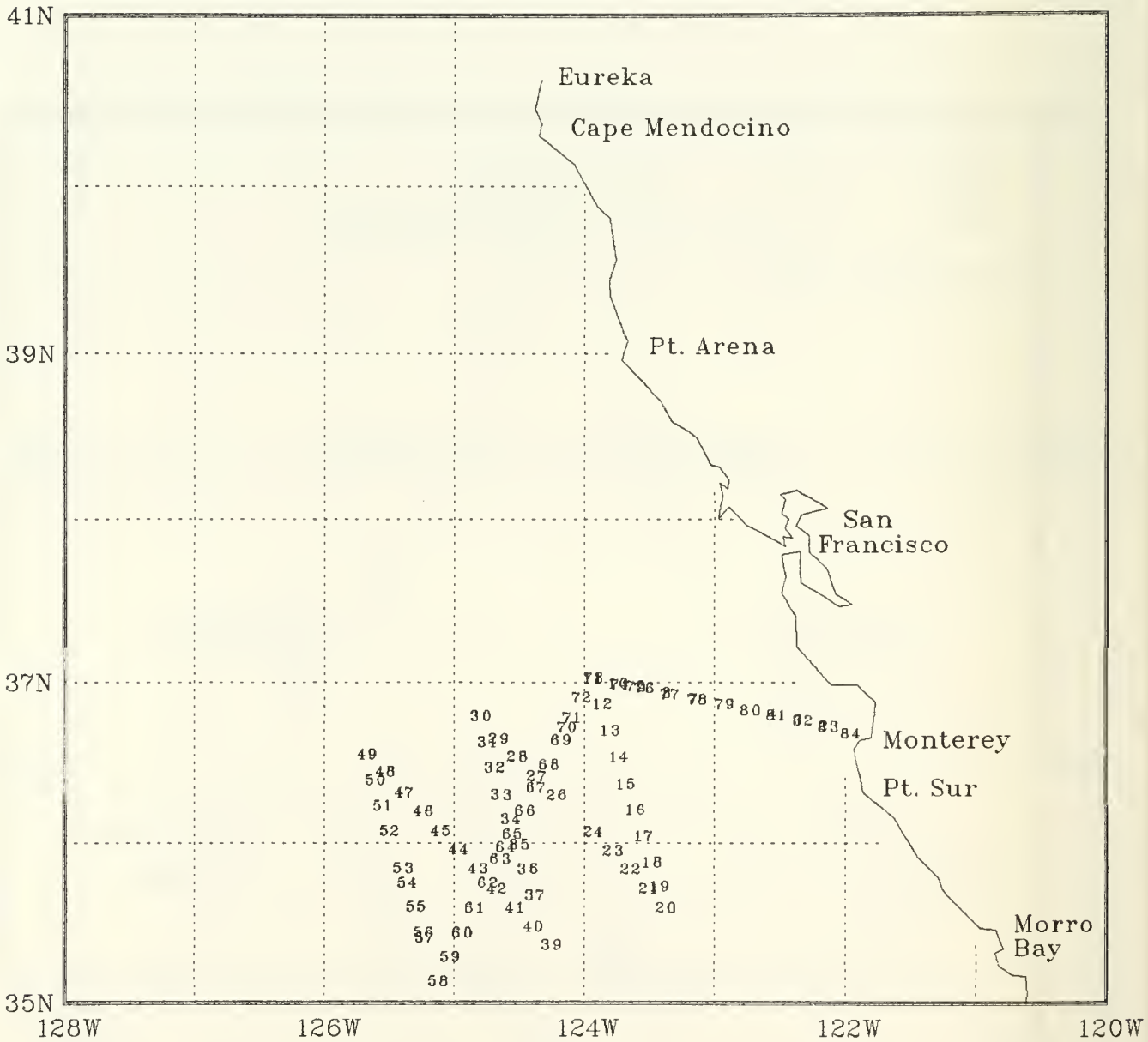



Figure 15: Station numbers for OPTOMA4, Leg II.

Table 3: Leg II Station Listing

| STN | TYPE | YR/DAY | GMT | LAT (NORTH) (DD.MM) | LONG (WEST) (DDD.MM) | SURFACE TEMP (DEG C) | SURFACE SALINITY (PPT) | BUCKET TEMP (DEG C) | BOTTLE SALINITY (PPT) |
|---|---|---|---|---|---|---|---|---|---|
| 2 | CTD | 83095 | 1716 | 36.42 | 122.12 | 12.8 | 32.87 | 12.8 | 32.94 |
| 3 | XBT | 83095 | 1900 | 36.45 | 122.23 | 12.9 | | | |
| 4 | XBT | 83095 | 2013 | 36.47 | 122.35 | 13.1 | | | |
| 7 | XBT | 83095 | 2357 | 36.52 | 123.12 | 13.8 | | | |
| 8 | CTD | 83096 | 107 | 36.54 | 123.24 | 13.4 | 31.31 | 13.0 | 31.32 |
| 9 | XBT | 83096 | 234 | 36.56 | 123.35 | 13.3 | | | |
| 10 | XBT | 83096 | 345 | 36.58 | 123.48 | 13.3 | | | |
| 11 | CTD | 83096 | 457 | 37.00 | 124.00 | 13.0 | 32.58 | 12.9 | 32.59 |
| 12 | XBT | 83096 | 703 | 36.50 | 123.56 | 12.9 | | | |
| 13 | XBT | 83096 | 808 | 36.41 | 123.52 | 13.1 | | | |
| 14 | CTD | 83096 | 917 | 36.31 | 123.48 | 13.4 | 33.02 | 13.2 | 32.94 |
| 15 | XBT | 83096 | 1044 | 36.21 | 123.45 | 13.6 | | | |
| 16 | XBT | 83096 | 1146 | 36.11 | 123.40 | 13.8 | | | |
| 17 | CTD | 83096 | 1254 | 36.01 | 123.36 | 13.6 | 32.65 | 13.2 | 32.64 |
| 18 | XBT | 83096 | 1419 | 35.51 | 123.33 | 13.9 | | | |
| 19 | XBT | 83096 | 1520 | 35.42 | 123.29 | 13.9 | | | |
| 20 | CTD | 83096 | 1620 | 35.34 | 123.27 | 13.7 | 32.28 | 13.8 | 32.26 |
| 21 | XBT | 83096 | 1845 | 35.41 | 123.35 | 14.2 | | | |
| 22 | XBT | 83096 | 2001 | 35.49 | 123.43 | 13.8 | | | |
| 23 | CTD | 83096 | 2113 | 35.56 | 123.51 | 13.9 | 33.10 | 13.9 | 33.13 |
| 24 | XBT | 83096 | 2253 | 36.03 | 124.00 | 14.2 | | | |
| 26 | CTD | 83097 | 123 | 36.17 | 124.17 | 14.1 | 33.24 | 14.0 | 33.21 |
| 27 | XBT | 83097 | 314 | 36.24 | 124.26 | 14.3 | | | |
| 28 | XBT | 83097 | 435 | 36.31 | 124.35 | 14.3 | | | |
| 29 | XBT | 83097 | 551 | 36.37 | 124.44 | 14.7 | | | |
| 30 | CTD | 83097 | 746 | 36.46 | 124.52 | 14.0 | 33.25 | 13.8 | 33.28 |
| 31 | XBT | 83097 | 953 | 36.36 | 124.49 | 14.2 | | | |
| 32 | XBT | 83097 | 1057 | 36.27 | 124.46 | 14.7 | | | |
| 33 | CTD | 83097 | 1210 | 36.16 | 124.43 | 14.3 | 33.45 | 14.3 | 33.44 |
| 34 | XBT | 83097 | 1339 | 36.08 | 124.38 | 14.7 | | | |
| 35 | XBT | 83097 | 1445 | 35.58 | 124.34 | 14.4 | | | |
| 36 | CTD | 83097 | 1548 | 35.49 | 124.31 | 14.1 | 33.28 | 14.1 | 33.27 |
| 37 | XBT | 83097 | 1719 | 35.39 | 124.27 | 14.0 | | | |
| 39 | CTD | 83097 | 1933 | 35.20 | 124.20 | 14.1 | 33.19 | 14.0 | 33.18 |
| 40 | XBT | 83097 | 2204 | 35.27 | 124.28 | 13.6 | | | |
| 41 | XBT | 83097 | 2323 | 35.34 | 124.36 | 14.2 | | | |
| 42 | CTD | 83098 | 107 | 35.41 | 124.45 | 14.2 | 33.35 | 14.0 | 33.39 |
| 43 | XBT | 83098 | 343 | 35.49 | 124.54 | 14.2 | | | |
| 44 | XBT | 83098 | 531 | 35.56 | 125.03 | 14.1 | | | |
| 45 | CTD | 83098 | 808 | 36.03 | 125.11 | 14.2 | 33.27 | 13.9 | 33.29 |
| 46 | XBT | 83098 | 1115 | 36.10 | 125.19 | 14.1 | | | |
| 47 | XBT | 83098 | 1354 | 36.18 | 125.27 | 14.1 | | | |
| 48 | XBT | 83098 | 1556 | 36.25 | 125.36 | 14.1 | | | |
| 49 | CTD | 83098 | 1739 | 36.32 | 125.45 | 14.0 | 33.24 | 13.9 | 33.23 |
| 50 | XBT | 83098 | 1947 | 36.22 | 125.41 | 13.3 | | | |

| STN | TYPE | YR/DAY | GMT | LAT (NORTH) (DD.MM) | LONG (WEST) (DDD.MM) | SURFACE TEMP (DEG C) | SURFACE SALINITY (PPT) | BUCKET TEMP (DEG C) | BOTTLE SALINITY (PPT) |
|---|---|---|---|---|---|---|---|---|---|
| 51 | XBT | 83098 | 2054 | 36.13 | 125.37 | 14.2 | | | |
| 52 | CTD | 83098 | 2205 | 36.03 | 125.34 | 14.2 | 33.20 | 14.3 | 33.23 |
| 53 | XBT | 83099 | 10 | 35.49 | 125.28 | 14.6 | | | |
| 54 | XBT | 83099 | 49 | 35.44 | 125.26 | 14.2 | | | |
| 55 | CTD | 83099 | 156 | 35.35 | 125.22 | 14.3 | 33.29 | 14.2 | 33.28 |
| 56 | XBT | 83099 | 326 | 35.25 | 125.18 | 14.4 | | | |
| 57 | XBT | 83099 | 345 | 35.23 | 125.18 | 14.3 | | | |
| 58 | CTD | 83099 | 543 | 35.06 | 125.12 | 14.1 | 33.22 | 14.8 | 33.21 |
| 59 | XBT | 83099 | 809 | 35.16 | 125.06 | 14.0 | | | |
| 60 | XBT | 83099 | 923 | 35.25 | 125.01 | 14.1 | | | |
| 61 | CTD | 83099 | 1038 | 35.34 | 124.55 | 13.8 | 33.19 | 13.8 | 33.18 |
| 62 | XBT | 83099 | 1218 | 35.44 | 124.49 | 13.8 | | | |
| 63 | XBT | 83099 | 1332 | 35.53 | 124.43 | 14.1 | | | |
| 64 | XBT | 83099 | 1409 | 35.57 | 124.41 | 14.4 | | | |
| 65 | CTD | 83099 | 1451 | 36.02 | 124.38 | 14.3 | 33.49 | 14.1 | 33.49 |
| 66 | XBT | 83099 | 1717 | 36.11 | 124.32 | 14.2 | | | |
| 67 | XBT | 83099 | 1827 | 36.19 | 124.27 | 14.3 | | | |
| 68 | CTD | 83099 | 1936 | 36.28 | 124.21 | 14.3 | 33.45 | 14.3 | 33.45 |
| 69 | XBT | 83099 | 2124 | 36.37 | 124.15 | 14.1 | | | |
| 70 | XBT | 83099 | 2205 | 36.42 | 124.12 | 13.6 | | | |
| 71 | XBT | 83099 | 2237 | 36.45 | 124.10 | 12.9 | | | |
| 72 | XBT | 83099 | 2338 | 36.53 | 124.05 | 13.0 | | | |
| 73 | CTD | 83100 | 46 | 37.00 | 124.00 | 12.9 | 32.43 | 12.9 | 32.55 |
| 74 | XBT | 83100 | 258 | 36.58 | 123.48 | 12.7 | | | |
| 75 | XBT | 83100 | 341 | 36.57 | 123.40 | 12.9 | | | |
| 76 | XBT | 83100 | 404 | 36.56 | 123.37 | 13.2 | | | |
| 77 | CTD | 83100 | 515 | 36.54 | 123.25 | 13.3 | 31.54 | 12.6 | 31.76 |
| 78 | XBT | 83100 | 645 | 36.52 | 123.12 | 13.3 | | | |
| 79 | CTD | 83100 | 754 | 36.50 | 123.00 | 13.0 | 31.76 | 12.9 | 31.77 |
| 80 | XBT | 83100 | 919 | 36.48 | 122.48 | 13.2 | | | |
| 81 | CTD | 83100 | 1024 | 36.46 | 122.36 | 13.0 | 31.77 | 12.6 | 32.24 |
| 82 | XBT | 83100 | 1146 | 36.44 | 122.24 | 13.2 | | | |
| 83 | CTD | 83100 | 1247 | 36.42 | 122.12 | 12.7 | 32.23 | * | * |
| 84 | XBT | 83100 | 1407 | 36.39 | 122.02 | 12.3 | | | |

* Data not available

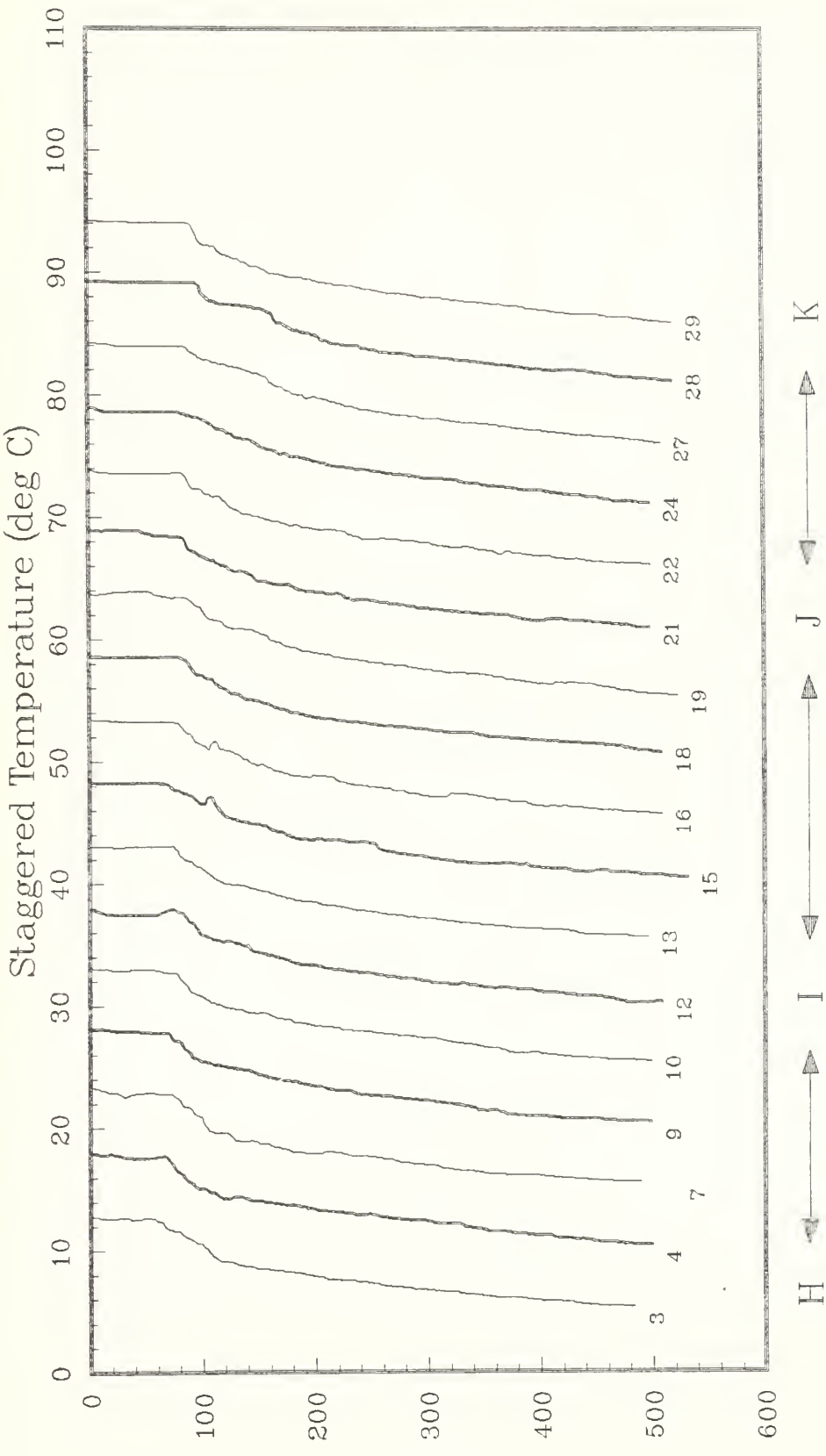



Figure 16(a): Staggered temperature profiles from the XBT's. Profiles are staggered by a multiple of 5C (OPTOMA4, Leg II).

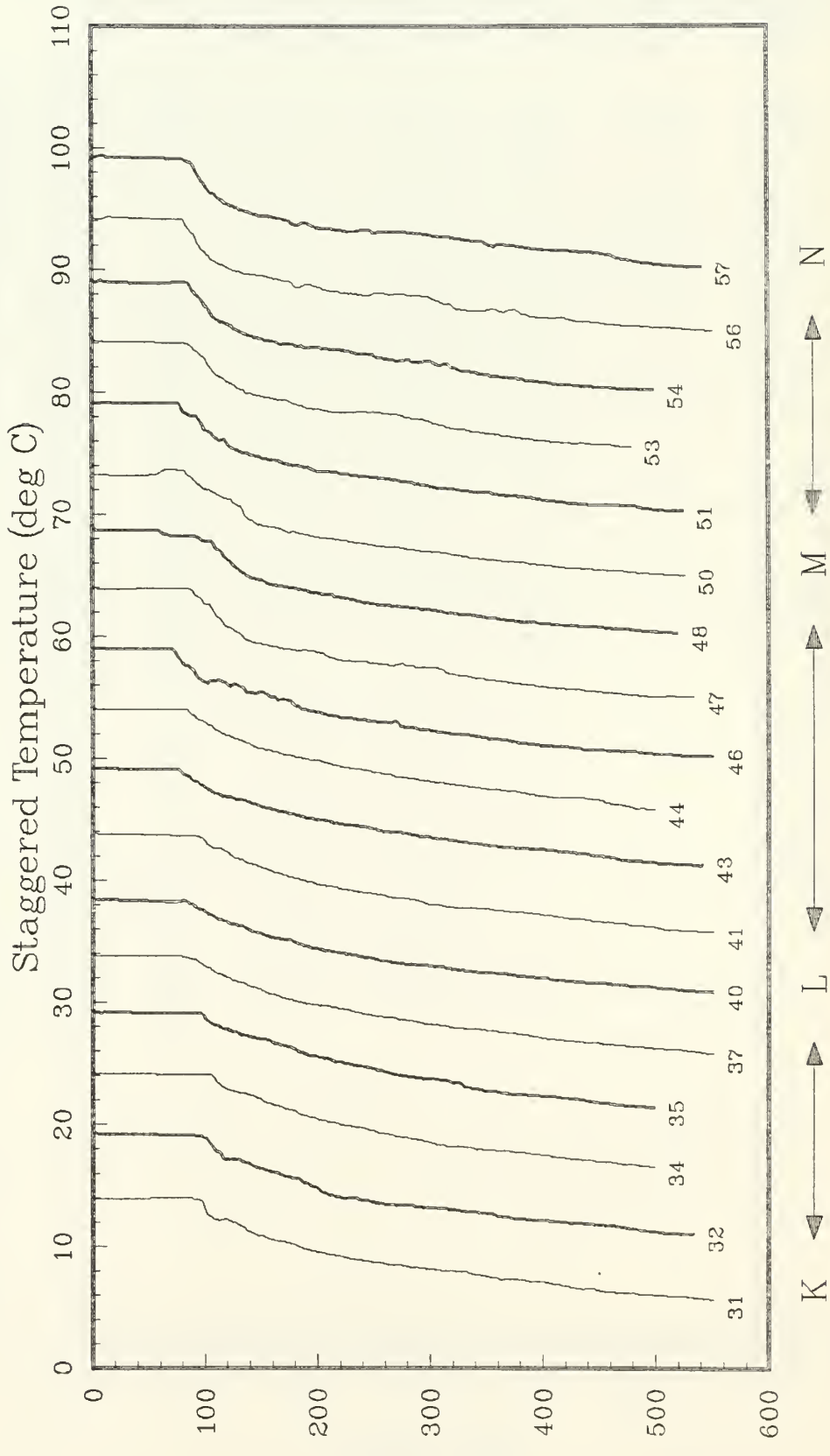

Staggered Temperature (deg C)
0
10
20
30
40
50
60
70
80
90
100
110
Depth (m)
0
100
200
300
400
500
600
31
32
34
35
37
40
41
43
44
46
47
48
50
51
53
54
56
57
K
L
M
N

Figure 16(b)

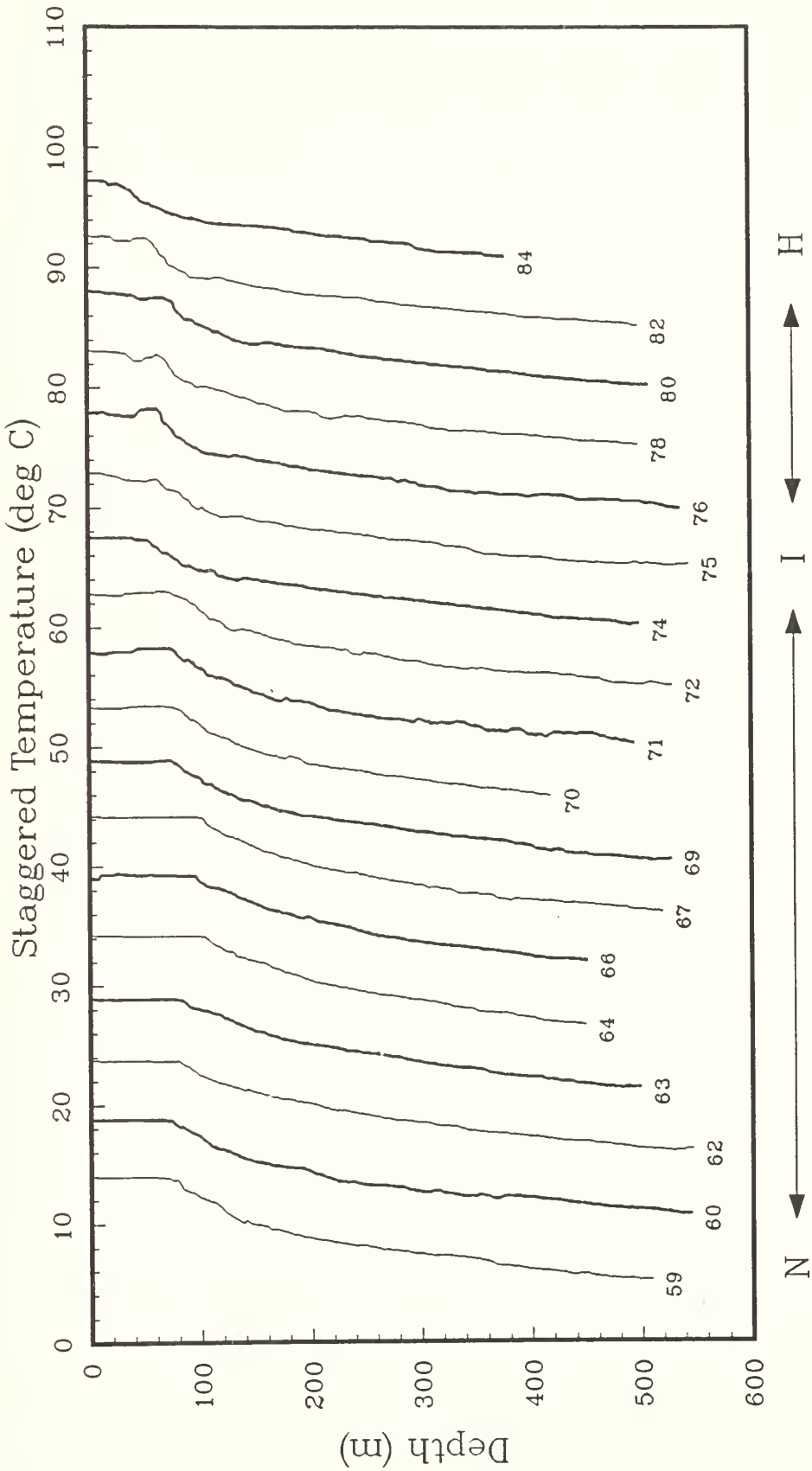

Staggered Temperature (deg C)
0
10
20
30
40
50
60
70
80
90
100
110
Depth (m)
0
100
200
300
400
500
600
59
60
62
63
64
66
67
69
70
71
72
74
75
76
78
80
82
84
N
I
H

Figure 16(c)

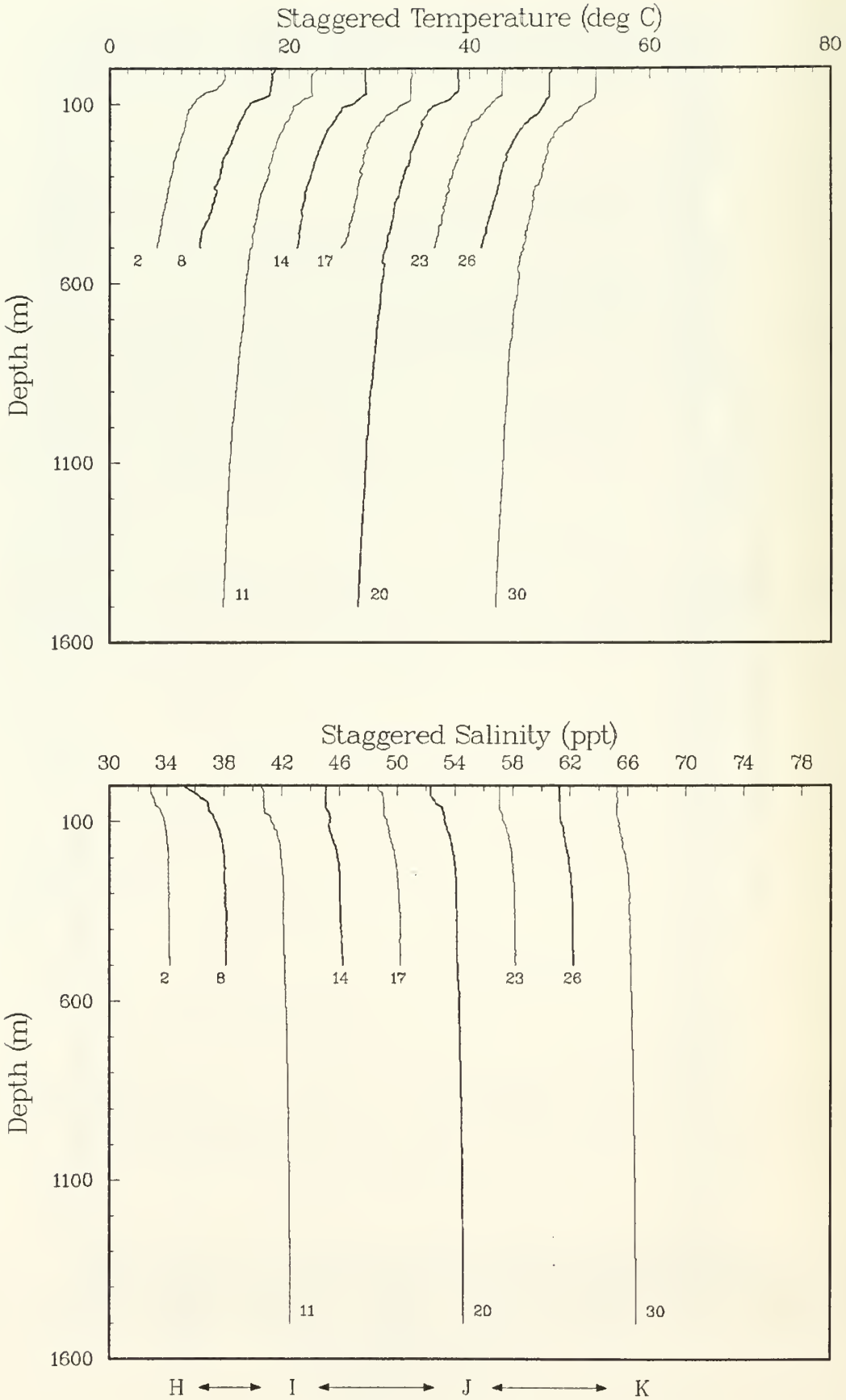
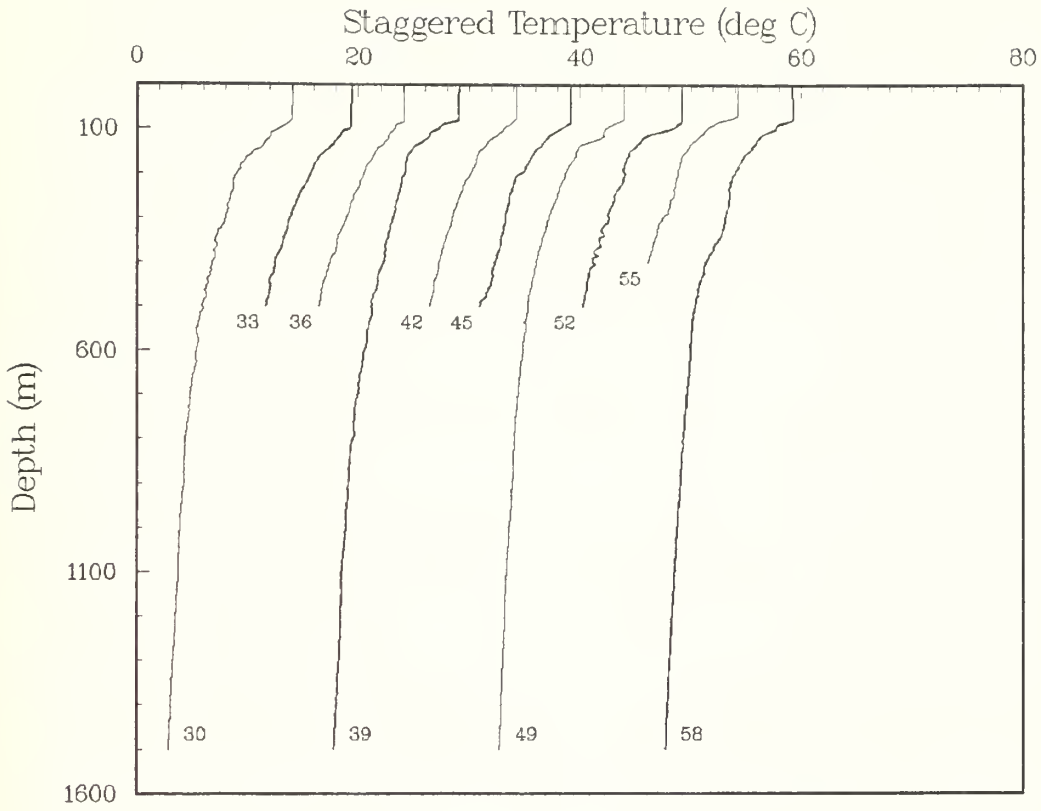



Figure 17(a): CTD temperature profiles, staggered by multiples of 5C, and salinity profiles staggered by multiples of 4 ppt (OPTOMA4, Leg II).


Staggered Temperature (deg C)
0
20
40
60
80
100
600
1100
1600
Depth (m)
33
36
42
45
52
55
30
39
49
58

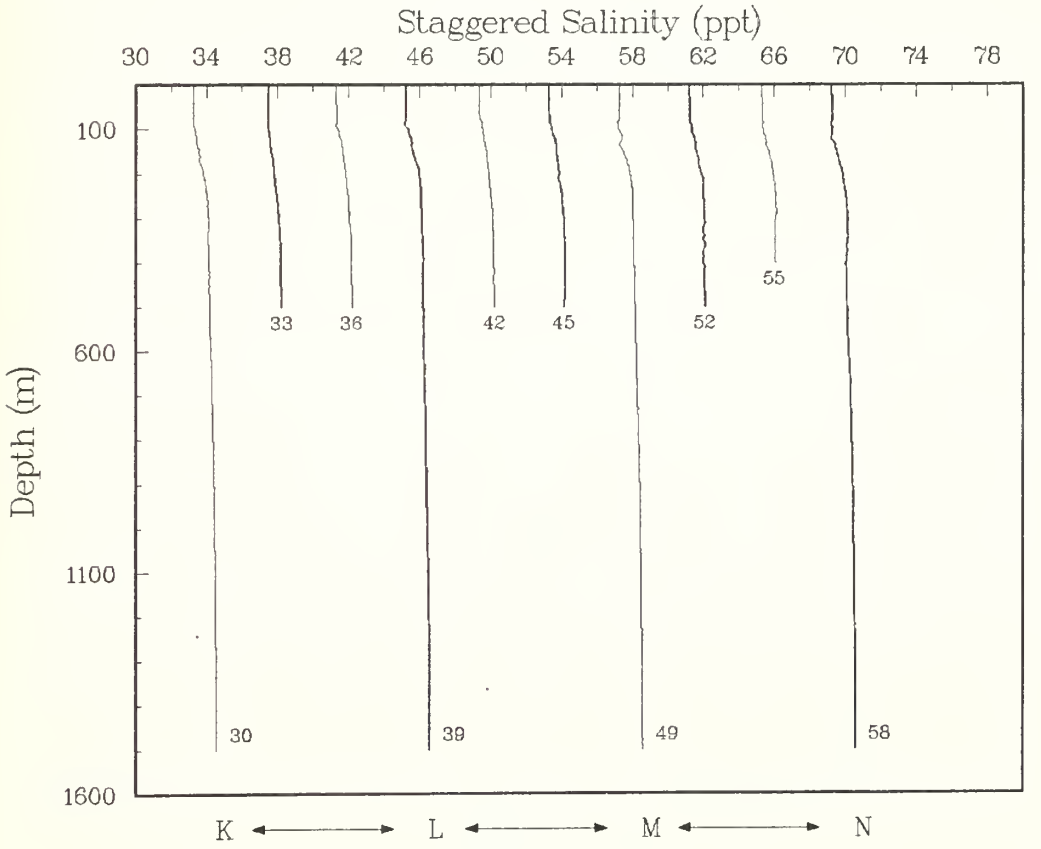
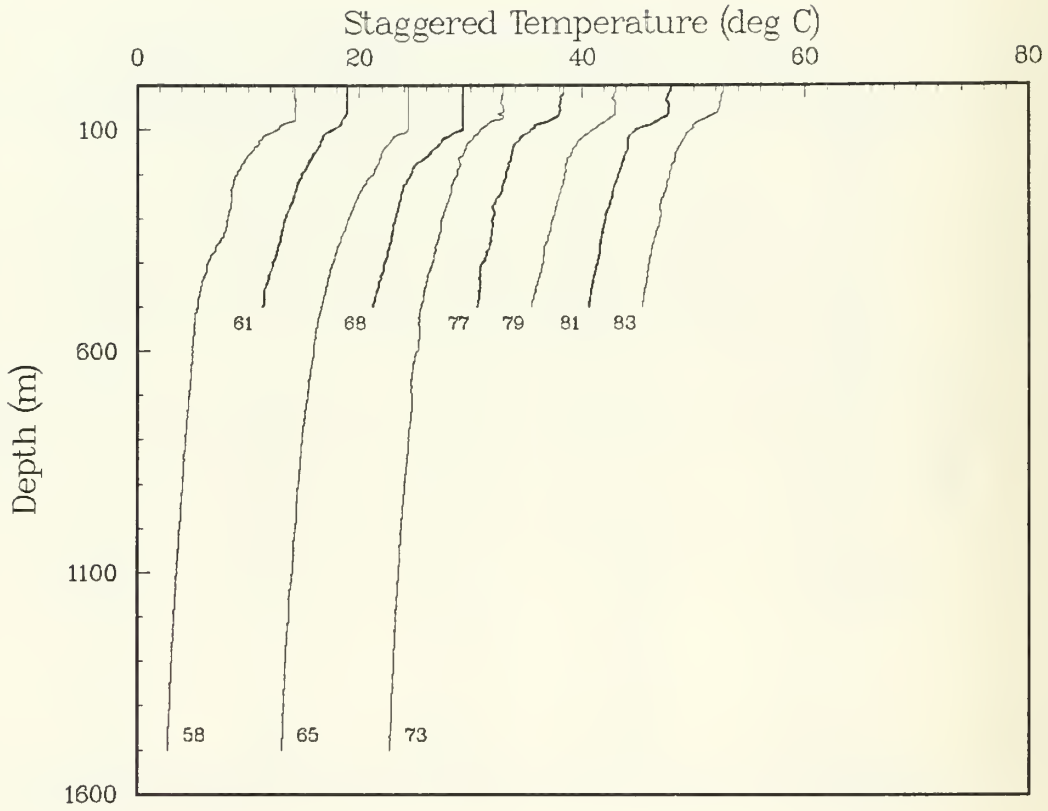

Staggered Salinity (ppt)
30
34
38
42
46
50
54
58
62
66
70
74
78
100
600
1100
1600
Depth (m)
33
36
42
45
52
55
30
39
49
58
K
L
M
N

Figure 17(b)


Staggered Temperature (deg C)
0
20
40
60
80
100
600
1100
1600
Depth (m)
61
68
77
79
81
83
58
65
73

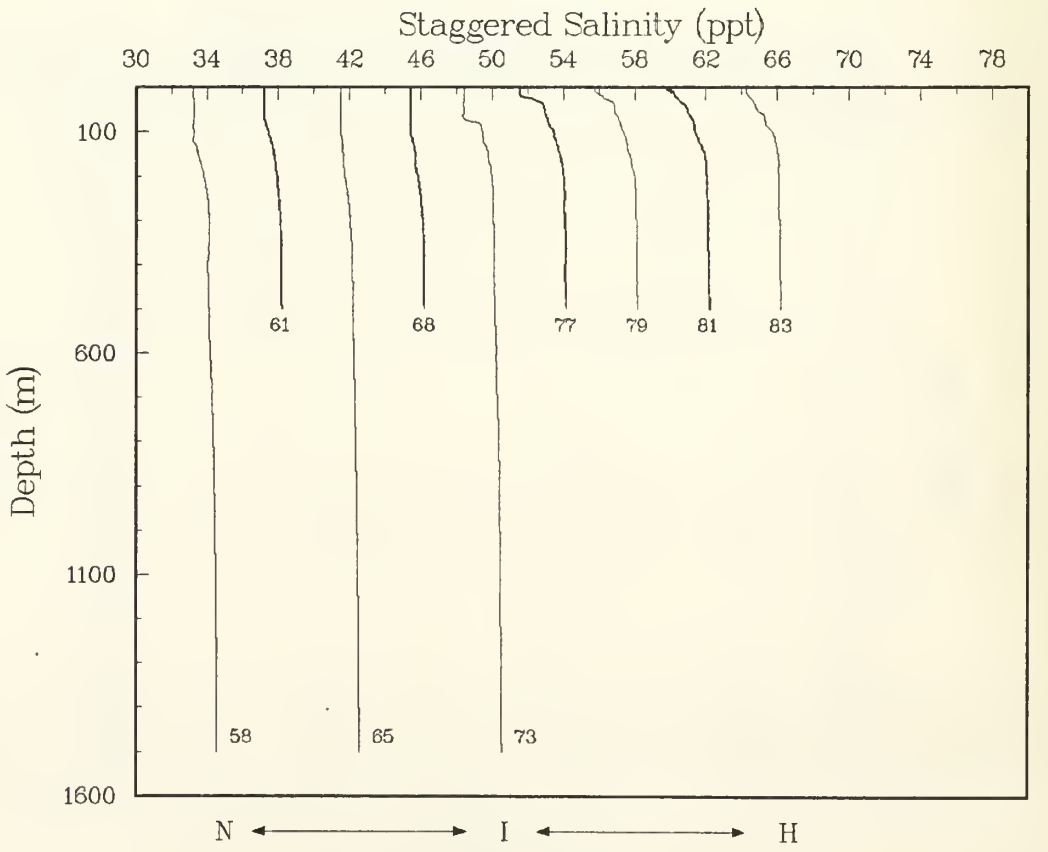
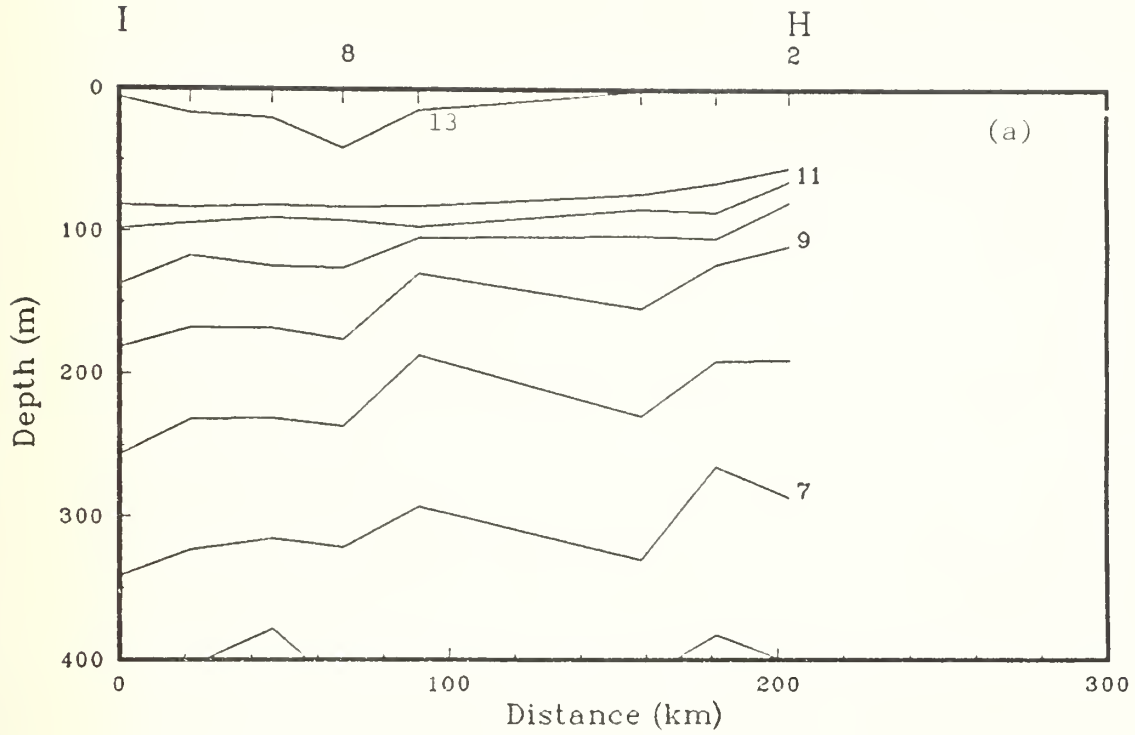

Staggered Salinity (ppt)
30
34
38
42
46
50
54
58
62
66
70
74
78
100
600
1100
1600
Depth (m)
61
68
77
79
81
83
58
65
73
N
I
H

Figure 17(c)



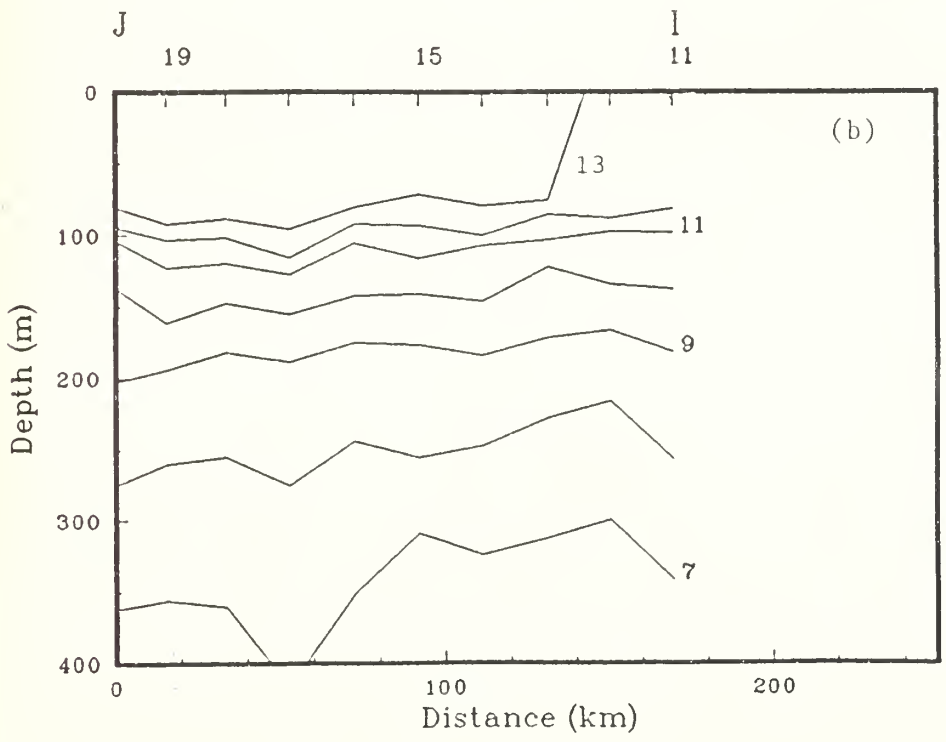




Figure 18(a), (b): Isotherms from XBT's and CTD's. Tick marks along the upper horizontal axis show station positions. Some station numbers are given (GPTOMA4, Leg II).

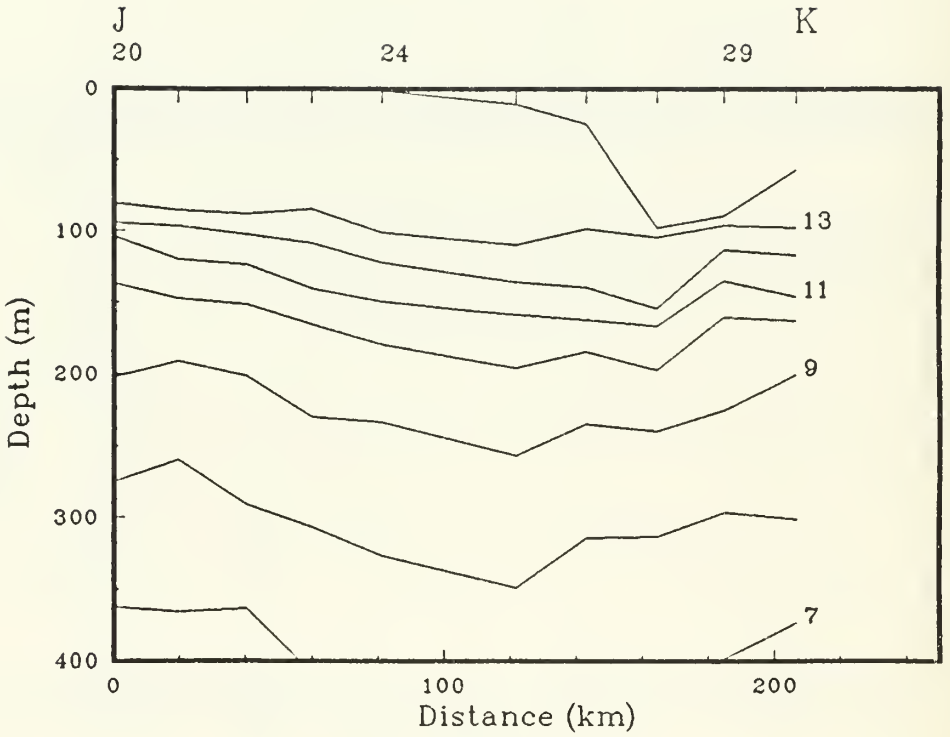



Figure 18(c)

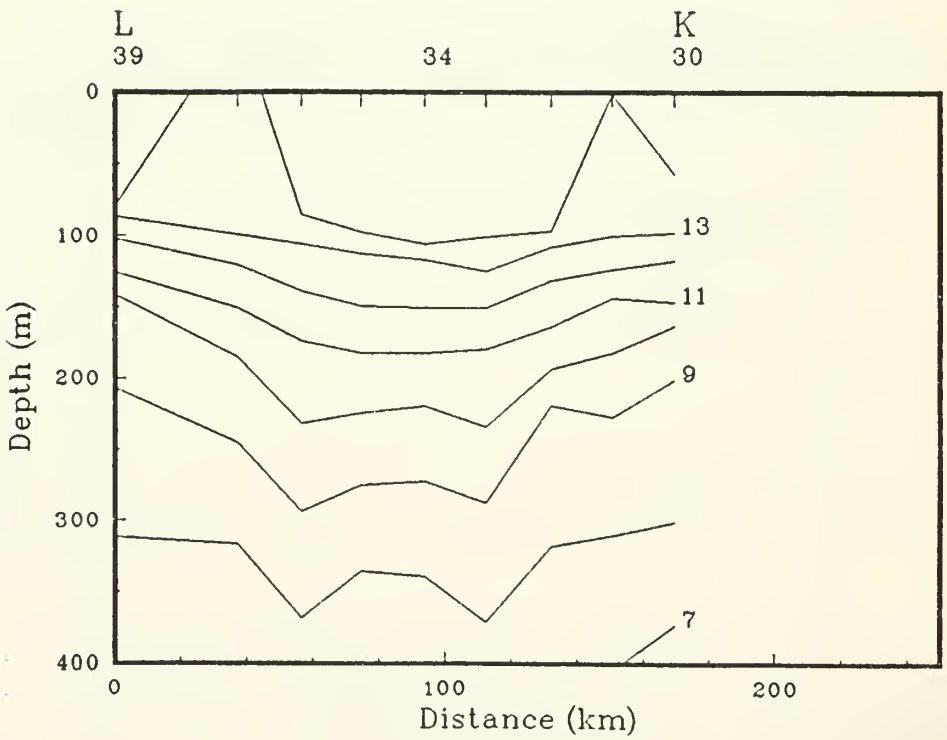



Figure 18(d)

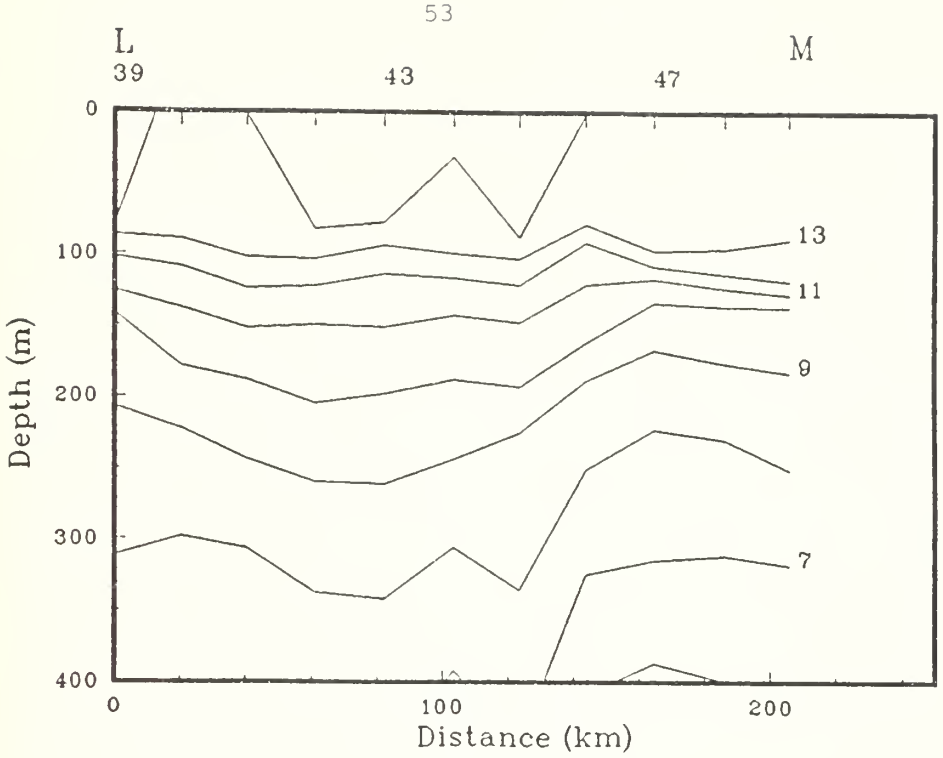



Figure 18(e)

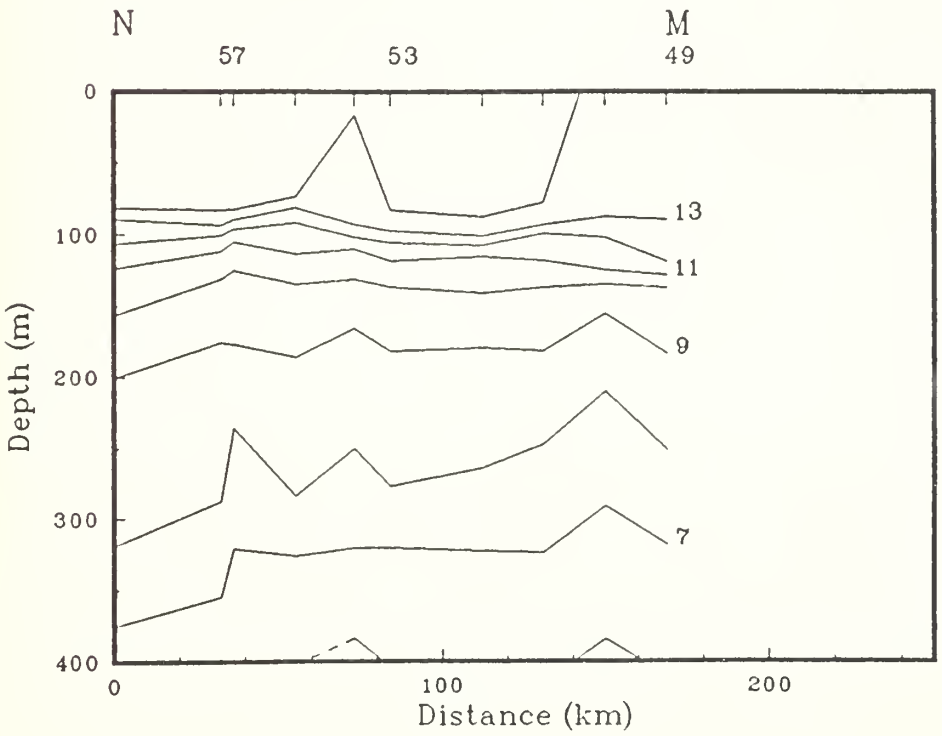



Figure 18(f)

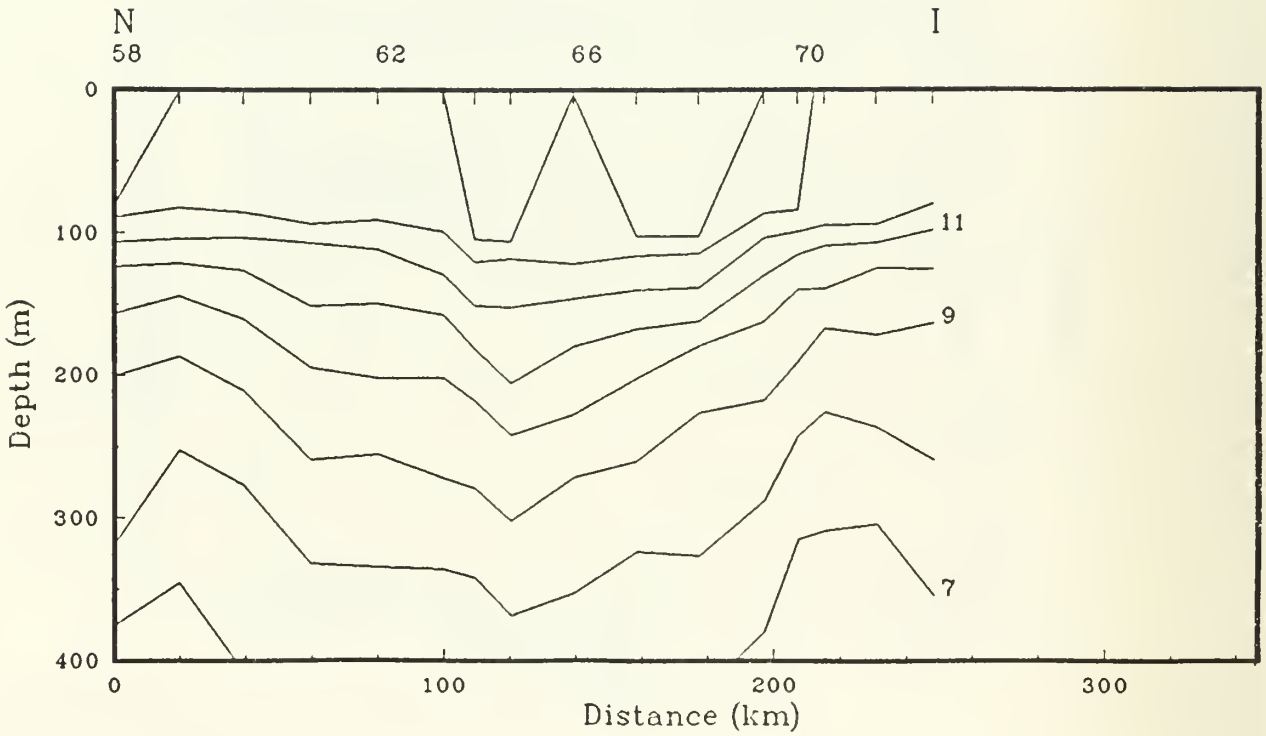



Figure 18(g)

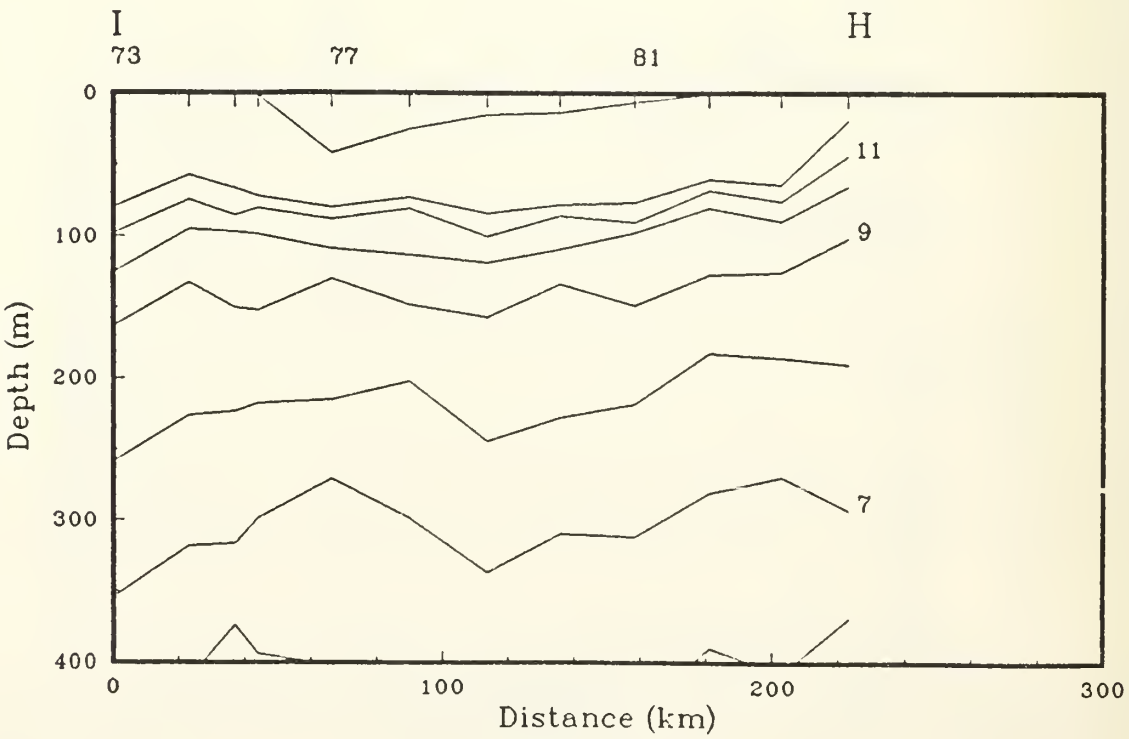



Figure 18(h)

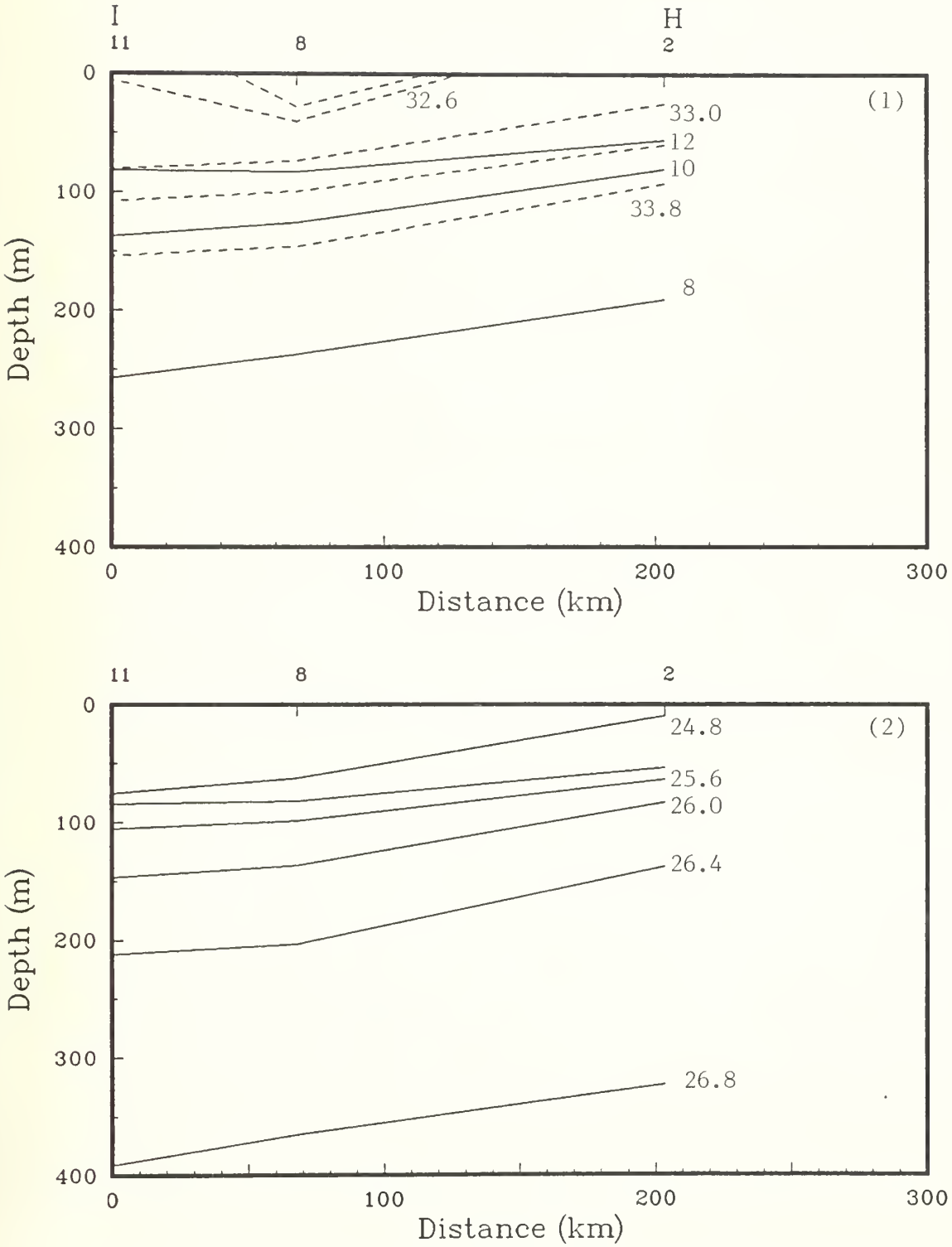



Figure 19(a): Isopleths of (1) temperature and salinity and (2) sigma-t from the CTD's (OPTOMA4, Leg II).

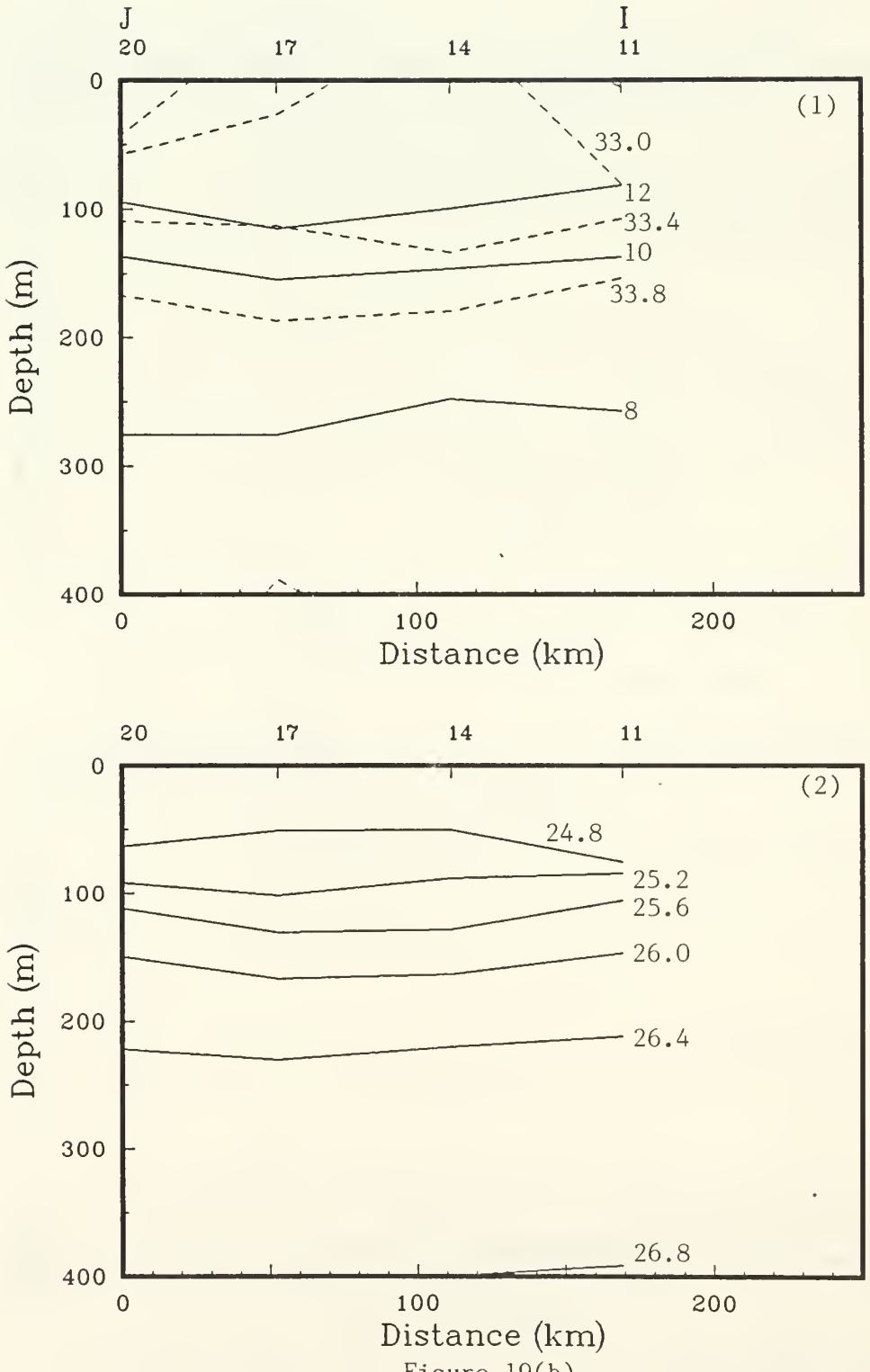

J
I
20
17
14
11
0
100
200
300
400
Depth (m)
(1)
33.0
12
33.4
10
33.8
8
0
100
200
Distance (km)
20
17
14
11
0
100
200
300
400
Depth (m)
(2)
24.8
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 19(b)

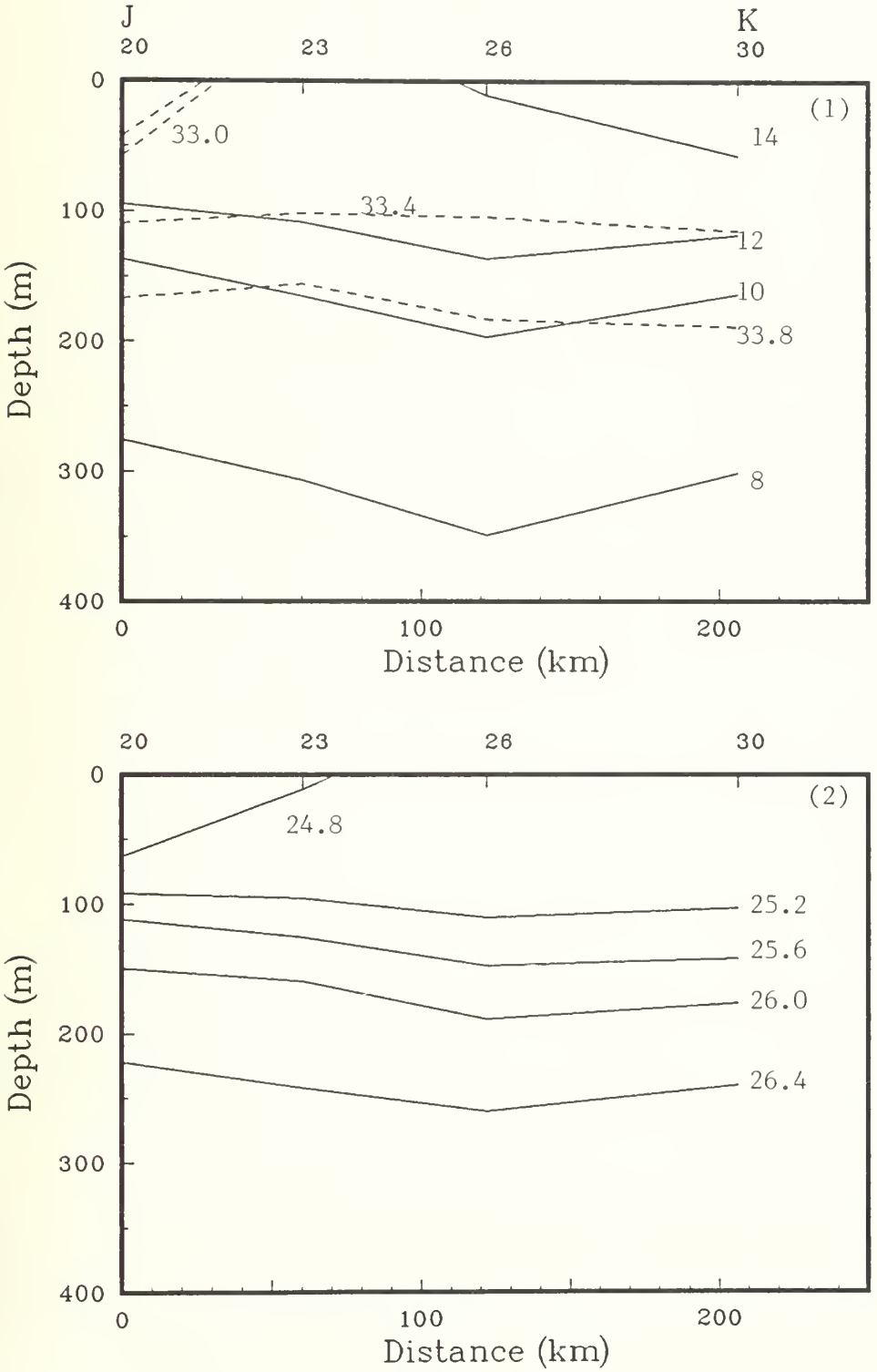

J
K
20
23
26
30
0
100
200
300
400
Depth (m)
(1)
33.0
14
33.4
12
10
33.8
8
0
100
200
Distance (km)
20
23
26
30
0
100
200
300
400
Depth (m)
(2)
24.8
25.2
25.6
26.0
26.4
0
100
200
Distance (km)

Figure 19(c)

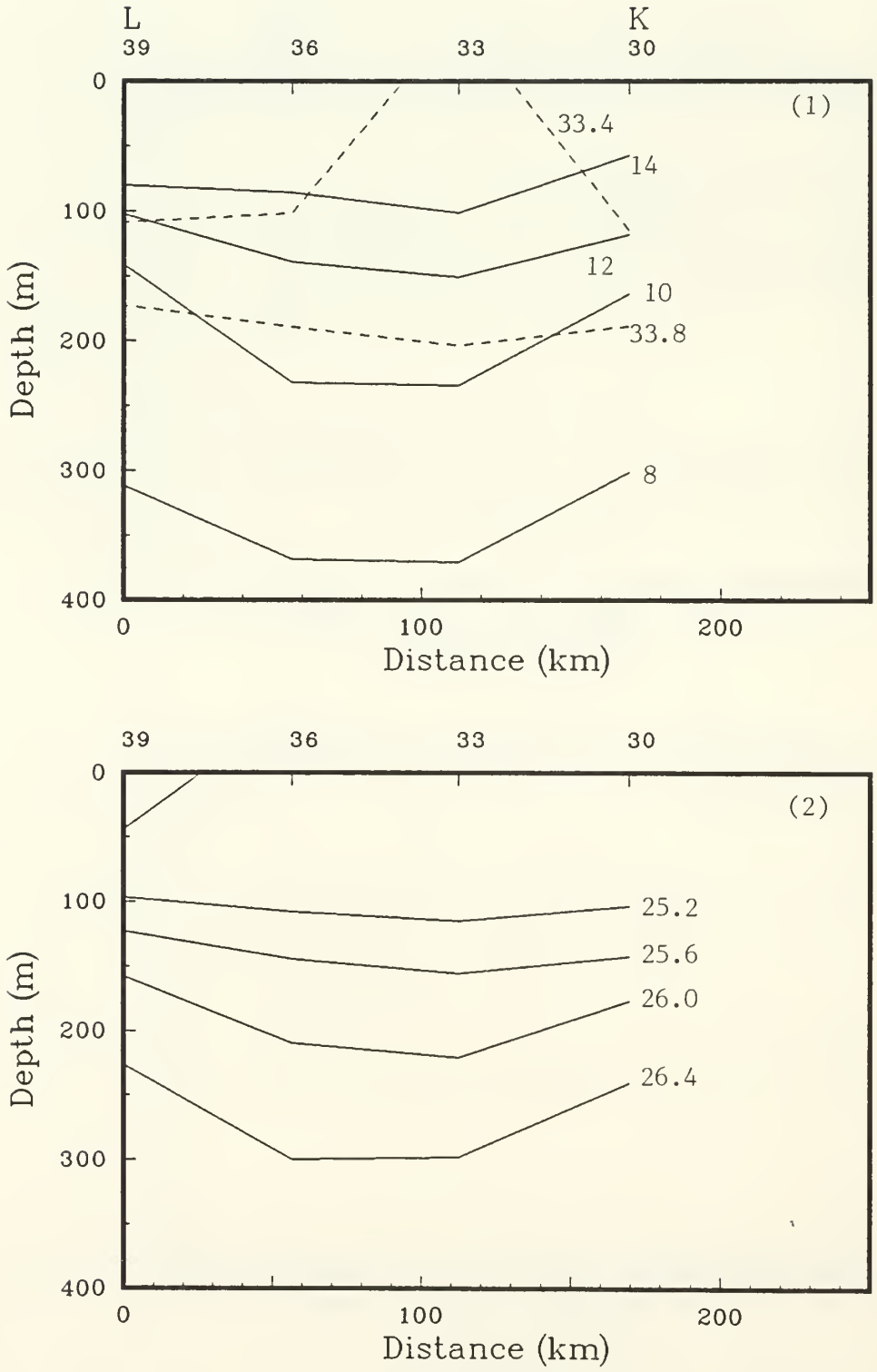

L
K
39
36
33
30
0
100
200
300
400
Depth (m)
(1)
33.4
14
12
10
33.8
8
0
100
200
Distance (km)
39
36
33
30
0
100
200
300
400
Depth (m)
(2)
25.2
25.6
26.0
26.4
0
100
200
Distance (km)

Figure 19(d)

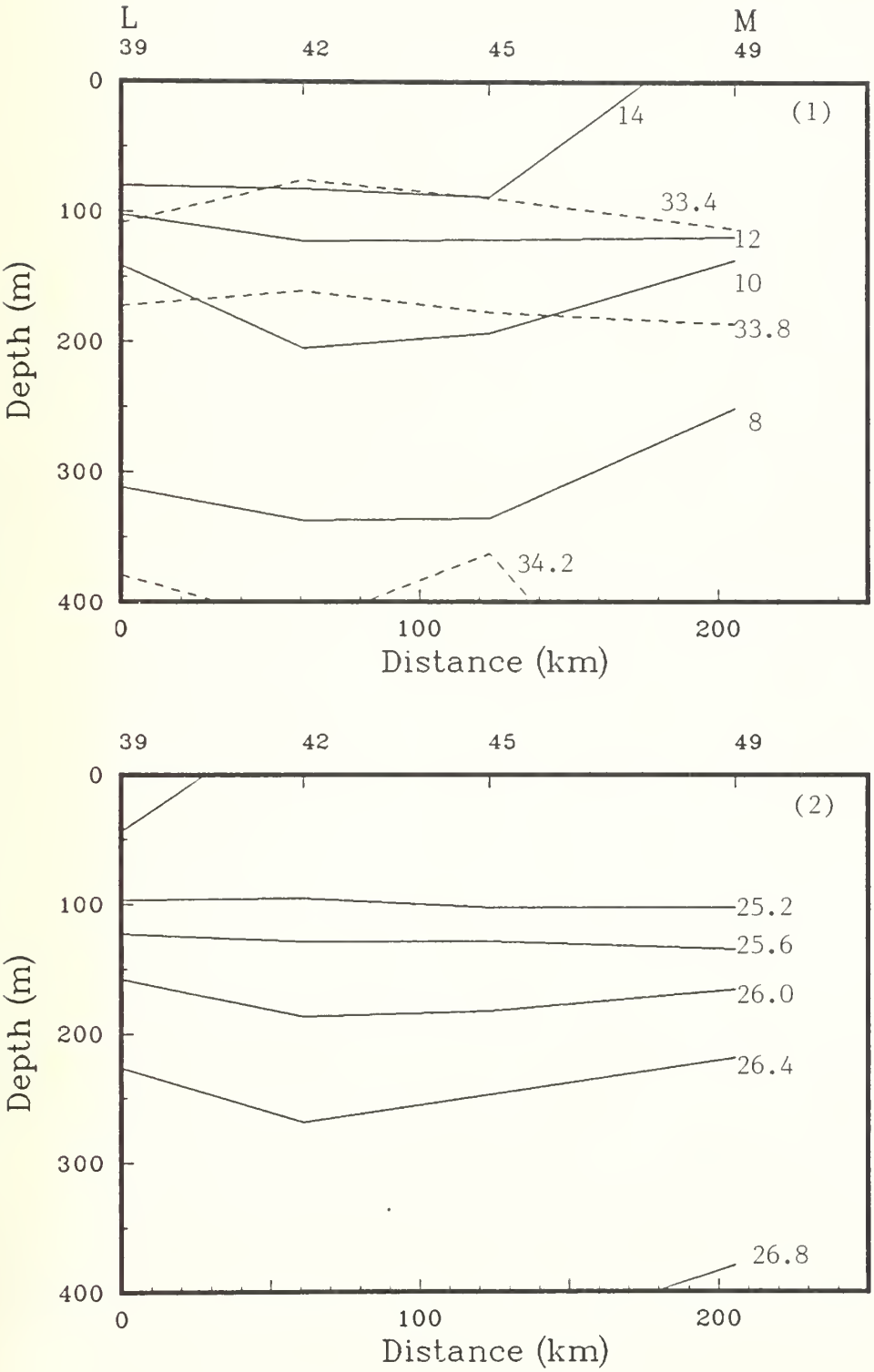

L
M
39
42
45
49
0
100
200
300
400
Depth (m)
14
(1)
33.4
12
10
33.8
8
34.2
0
100
200
Distance (km)
39
42
45
49
0
100
200
300
400
Depth (m)
(2)
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 19(e)

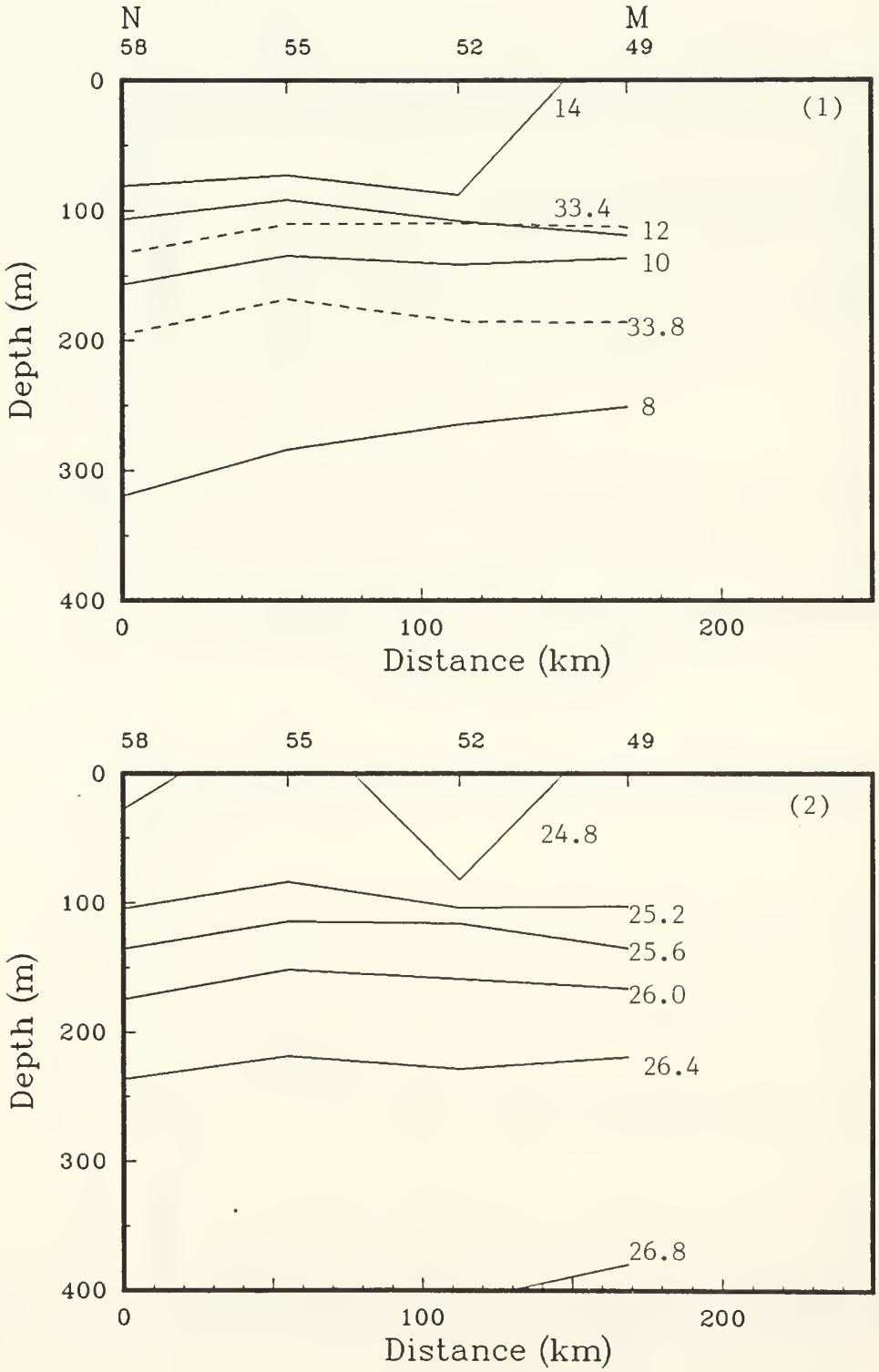

N
M
58
55
52
49
0
100
200
300
400
Depth (m)
14
(1)
33.4
12
10
33.8
8
0
100
200
Distance (km)
58
55
52
49
0
100
200
300
400
Depth (m)
(2)
24.8
25.2
25.6
26.0
26.4
26.8
0
100
200
Distance (km)

Figure 19(f)

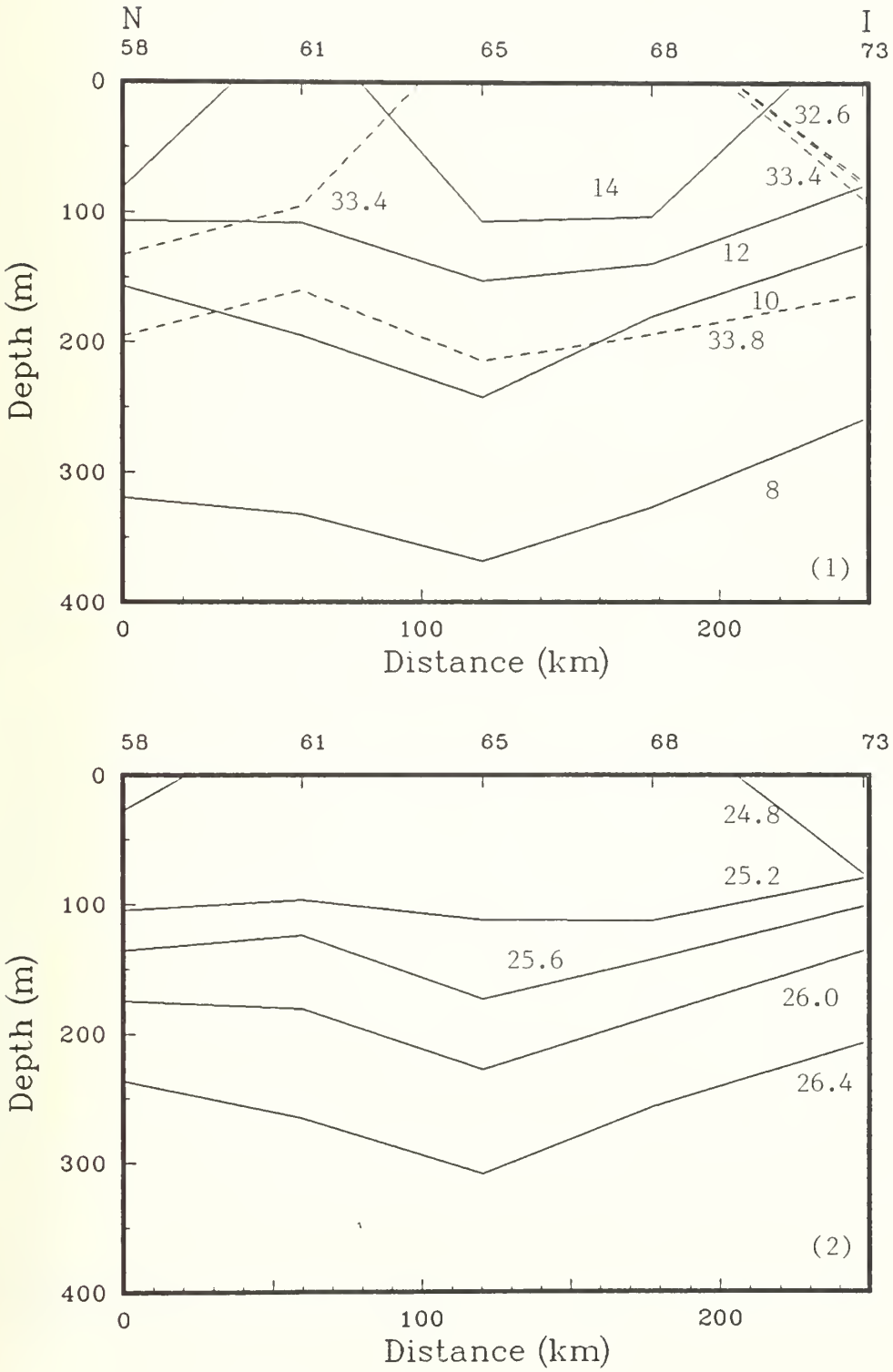

N
I
58
61
65
68
73
0
100
200
300
400
Depth (m)
32.6
33.4
14
33.4
12
10
33.8
8
(1)
0
100
200
Distance (km)
58
61
65
68
73
0
100
200
300
400
Depth (m)
24.8
25.2
25.6
26.0
26.4
(2)
0
100
200
Distance (km)

Figure 19(g)

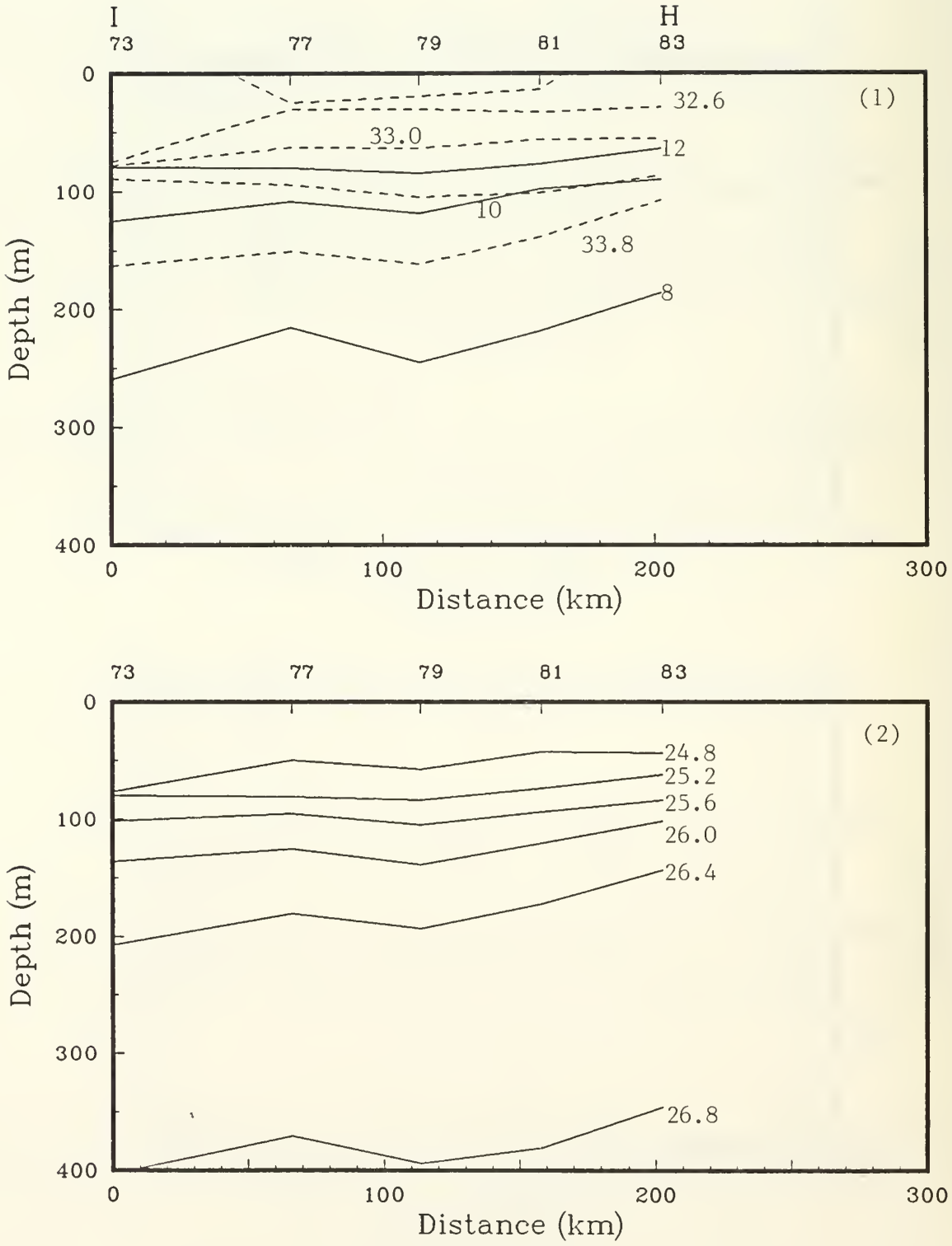

I
H
73
77
79
81
83
0
100
200
300
400
Depth (m)
(1)
32.6
33.0
12
10
33.8
8
Distance (km)
(2)
24.8
25.2
25.6
26.0
26.4
26.8

Figure 19(h)

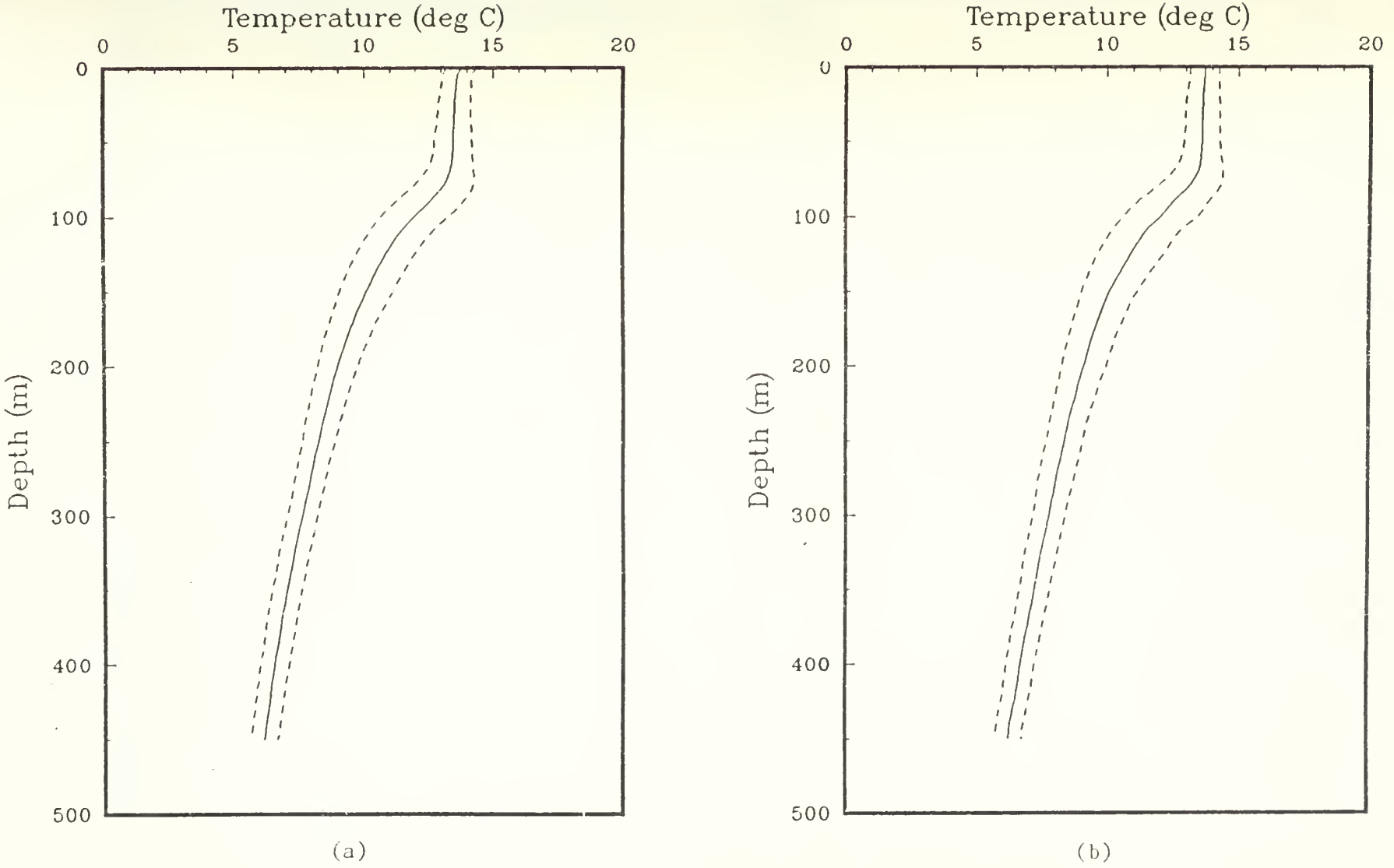



Figure 20 : Profile of $\overline{T(z)}$ with + and - the standard deviation from (a) XBT's and (b) CTD's (OPTOMA4, Leg II).

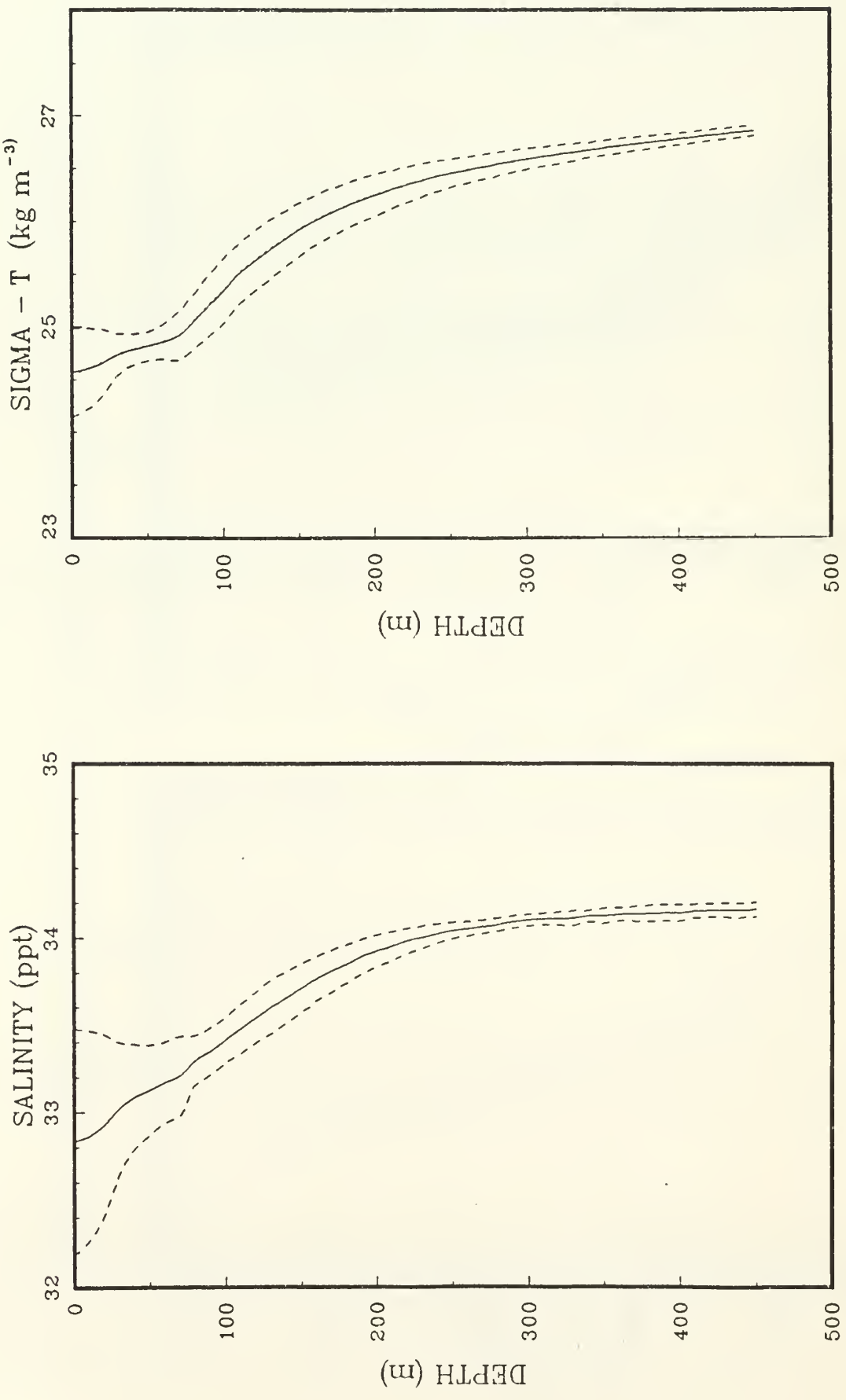



Figure 21 : Profiles of (a) mean salinity and (b) mean sigma-t, with + and - the standard deviations, from the CTD's (OPTOMA4, Leg II).

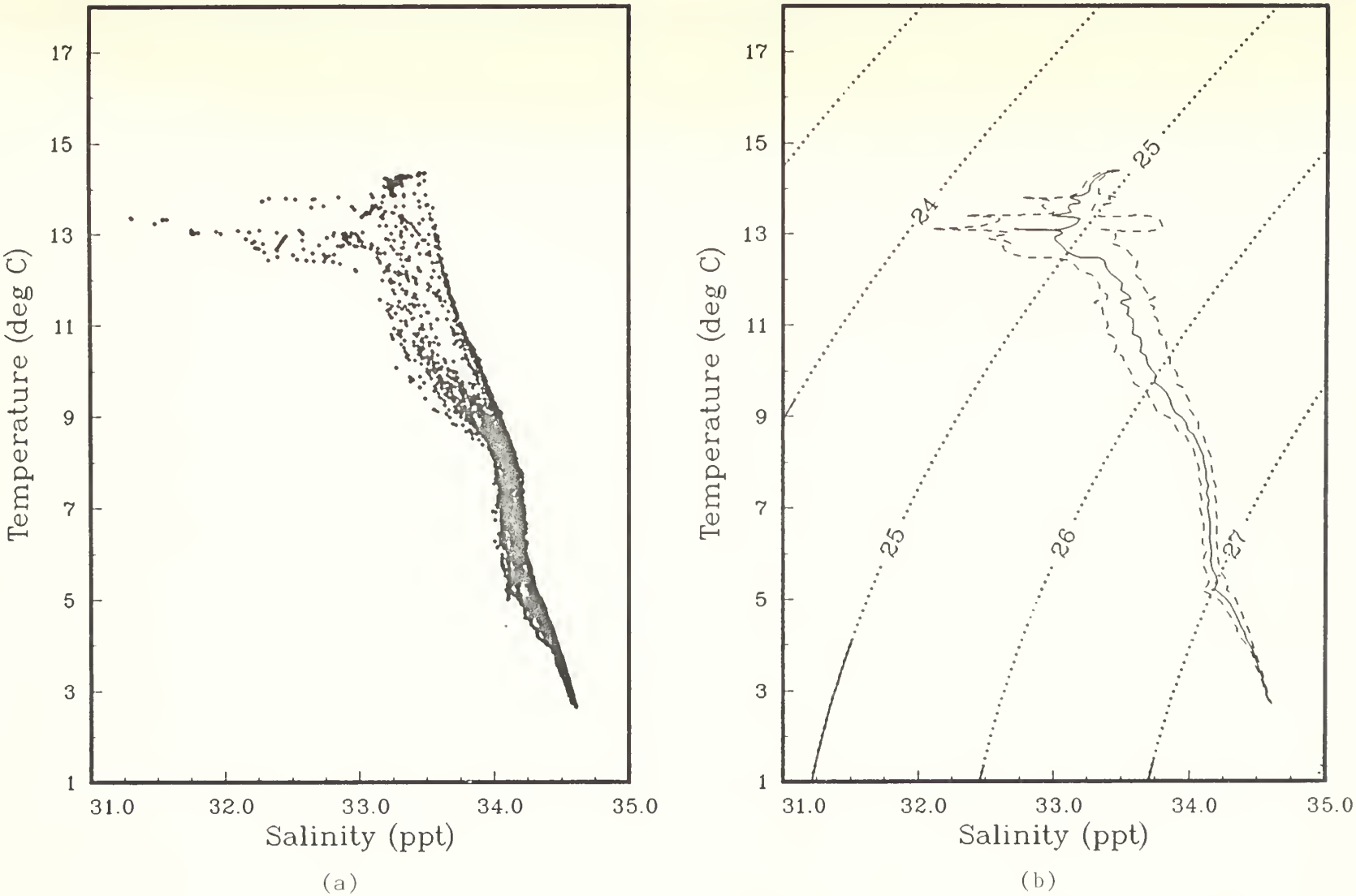



Figure 22: (a) T-S pairs and (b) mean T-S relationship, with + and - the standard deviation, and selected sigma-t contours, from the CTD casts (OPTOMA4, Leg II).

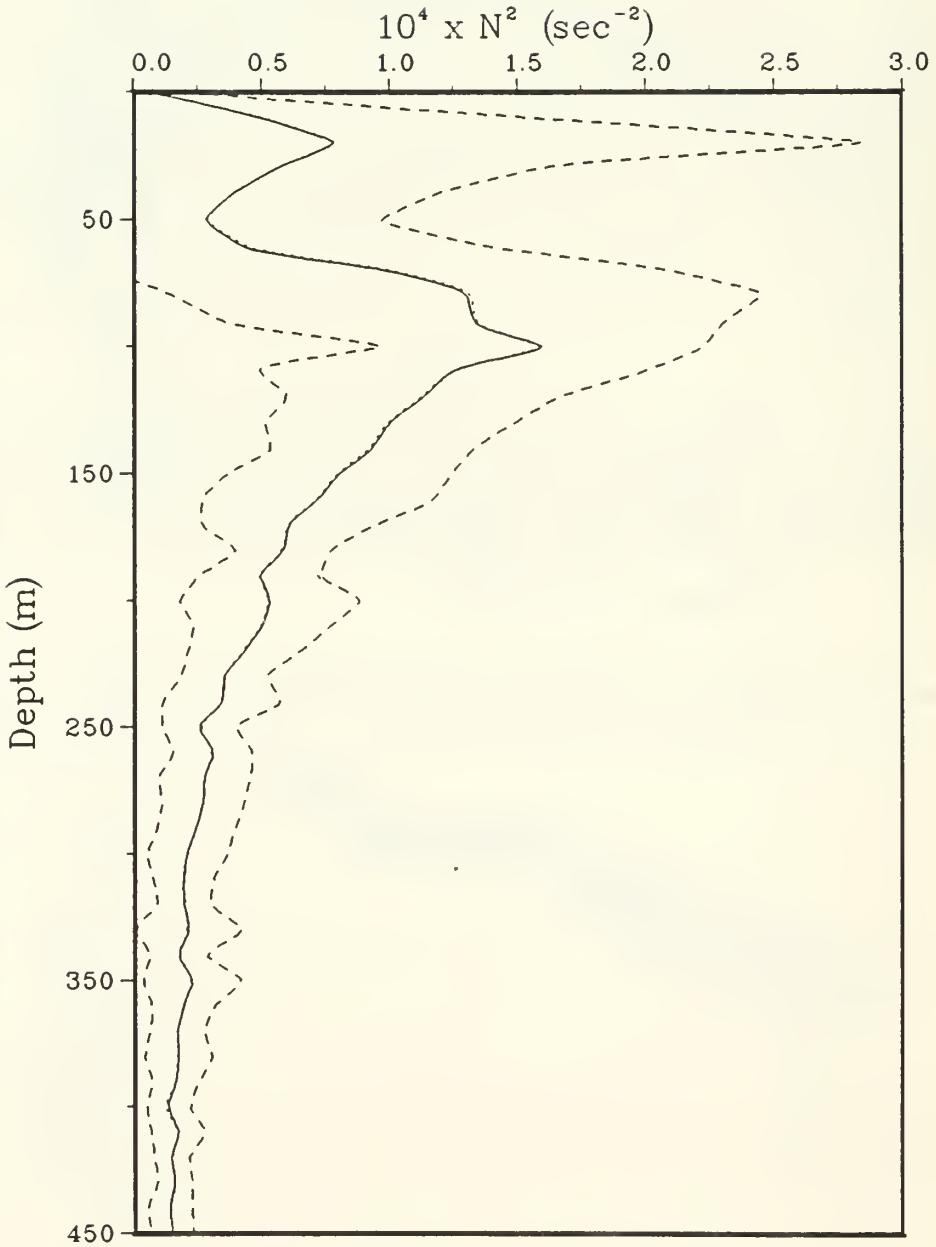



Figure 23: Profile of $\overline{N^2(z)}$ (____), with + and - the standard deviation (---), and the profile of $N^2$ from $\overline{T(z)}$ and $\overline{S(z)}$ (...) (OPTOMA4, Leg II).

## ACKNOWLEDGEMENTS

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Mr. Jim Stockel, NPS, Party Chief
Mr. Geoffrey Flyer, NPS
Ms. Marie Colton, NPS
AG2 Bratun, FNOC
ET3 Rief, FNOC

Leg II - Prof. Christopher N.K. Mooers, NPS, Chief Scientist
Mr. Jim Stockel, NPS, Party Chief
Mr. Geoffrey Flyer, NPS
Dr. Denise Hagan, JPL
Ms. Suzanne Healy, MLML
Ms. Martha Began, MLML

## REFERENCE

Lewis, E.L. and R.G. Perkin, 1981: The Practical Salinity Scale 1978: conversion of existing data. Deep Sea Res. 28A, 307-328.

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